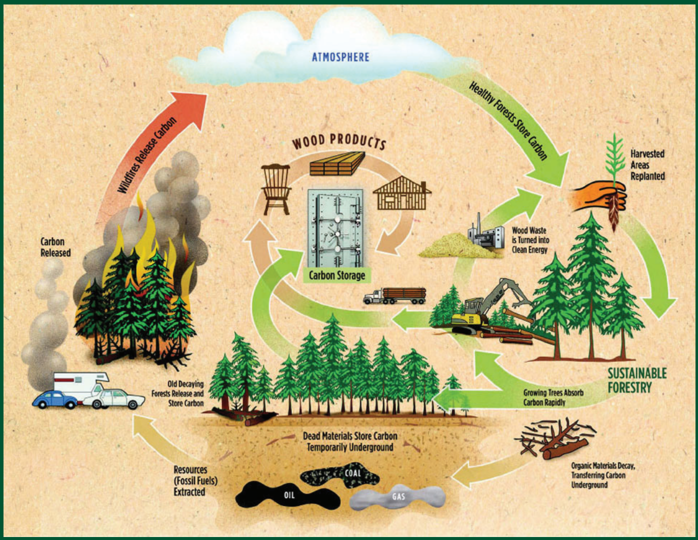
YALE PROGRAM ON STRATEGIES FOR THE FUTURE OF CONSERVATION

Land Conservation in a Changing Climate: Stewardship Science and Financing

Report of the 2016 Berkley Workshop

Held at the Pocantico Center of the Rockefeller Brothers Fund, Tarrytown, NY
July 2016

Bradford S. Gentry, Shelley Clark, Colin Kelly and Joshua Morse



Conservation Finance
From Niche to Mainstream:
The Building of an
Institutional Asset Class

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YALE SCHOOL OF FORESTRY & ENVIRONMENTAL STUDIES 2016

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Introduction and Participants

Bradford S. Gentry
Yale School of Forestry & Environmental Studies

The "Berkley Workshops" are an annual exploration into the future of land conservation. Convened by Yale University and the Land Trust Alliance, each workshop explores a particular topic that most land trusts have not had the time, energy, or relationships to address. It does so by bringing together experts with whom land trusts would not typically collaborate in their daily work.

In 2016, the workshop focused on "Land Conservation in a Changing Climate: Stewardship Science and Financing." The purpose of this section is to introduce the topic, recognize the workshop participants, and describe the remainder of this background paper.

The traditional strengths of the land conservation community have been in science – understanding the structures and functions of natural systems – and in finance – accessing the resources necessary to acquire and steward natural areas. As noted in the most recent U.S. Climate Assessment (2014), it is time to ensure that these strengths are being used to help address our changing climate:

> "Climate change, once considered an issue for a distant future, has moved firmly into the present. Corn producers in Iowa, oyster growers in Washington State, and maple syrup producers in Vermont are all observing climate-related changes that are outside of recent experience. So, too, are coastal planners in Florida, water managers in the arid Southwest, city dwellers from Phoenix to New York, and Native Peoples on tribal lands from Louisiana to Alaska. This National Climate Assessment concludes that the evidence of human-induced climate change continues to strengthen and that impacts are increasing across the country."[1]

While increasing amounts of work are being done on how climate change affects the selection of lands to be acquired,[2] comparatively less attention has been paid to the implications

1 Melillo, Jerry M., Terese (T.C.) Richmond, and Gary W. Yohe, Eds., 2014: *Highlights of Climate Change Impacts in the United States: The Third National Climate Assessment.* U.S. Global Change Research Program.

2 Such as the Open Space Institute's "Resilient Landscapes Initiative," see http://www.osiny.org/site/PageServer?pagename=Issues_Habitat

of a changing climate for the stewardship of already conserved lands – both in terms of the implications for the habitats and conservation values for which the lands were acquired, as well as how conserved lands might help address the likely impacts of climate change going forward.

In addition to what the science is telling us about our changing climate, now is also a good time to explore these stewardship opportunities given that:

- Governments from the municipal to national scales are allocating attention and resources to climate change more visibly and seriously than ever before.
- The science of climate change is becoming sophisticated enough that land managers can increasingly take concrete steps to address climate change impacts with a high degree of confidence.
- The land trust community is at two key points of transition, both of which interface directly with climate change:
  - The emergence of a new generation of conservation leaders, who have grown up in a world increasingly concerned with climate change, and
  - The continuing shift from acquisition-focused conservation to stewardship-focused conservation, which requires that land trusts think seriously about what it means to be responsible in perpetuity for land that will be subject to significant environmental shifts.

Taken together, these conditions create an environment where the land trust community has several fruitful opportunities to engage with climate change as an avenue of growth – and where the risks of not doing so are increasingly clear.

As such, the purpose of the 2016 Berkley Workshop was for the participants to explore some of the ways that land conservation groups might best help respond to our changing climate through their stewardship activities. The participants represent a wide range of perspectives, (see list below), and the structure for the workshop was designed to encourage creative interactions. At the end of the workshop, each participant was asked to identify specific action steps they may take (alone or in combination with others) and areas in need of further research. Yale will publish the workshop proceedings. The Land Trust Alliance will distribute the findings and areas for action to the land trust community via social media, including video interviews with workshop participants.

Participants

- *Avery Anderson, Founder and Principal, Impairative, NM*
- *Judy Anderson, Founder and Principal, Community Consultants, NY*
- *Barbara Bedford, Professor, Cornell University, NY*
- *Forrest Berkley, Board Member, Maine Coast Heritage Trust, ME*
- *Eron Bloomgarden, Partner, Encourage Capital, NY*
- *Andrew Bowman, President, The Land Trust Alliance, DC*
- *Cody Desautel, Land and Property Director, Confederated Tribes of the Colville Reservation, WA*
- *Kim Elliman, President, Open Space Institute, NY*
- *Jay Espy, President, Elmina B. Sewall Foundation, ME*
- *Robert Garcia, Founding Director and Counsel, The City Project, CA*
- *Brad Gentry, Associate Dean, Yale School of Forestry & Environmental Studies, CT*
- *Lara Hansen, Chief Scientist and Executive Director, EcoAdapt, WA*
- *Rick Huffines, Executive Director, Tennessee River Gorge Trust, TN*
- *Hilary Irby, Head of Investing With Impact, Morgan Stanley, NY*
- *Dylan Jenkins, Vice President of Portfolio Development, Finite Carbon, PA*
- *Chris Larson, President and Chief Executive Officer, New Island Capital, CA*
- *Tom Lautzenheiser, Central/West Regional Scientist, Mass Audubon, MA*
- *Darren Long, Program Director, Climate Adaptation Fund, Wildlife Conservation Society, MT*
- *Rue Mapp, Founder, Outdoor Afro, CA*
- *Jen Molnar, Managing Director and Lead Scientist, Center for Sustainability Science, The Nature Conservancy, VA*
- *Smita Rawoot, Associate Director, Service Implementation, 100 Resilient Cities, NY*
- *Mary Scoonover, Executive Vice President, Resources Legacy Fund, CA*
- *Marc Smiley, Principal, Solid Ground Consulting, OR (facilitator)*
- *Bruce Stein, Director, Climate Change Adaptation, National Wildlife Federation, DC*
- *Peter Stein, Managing Partner, The Lyme Timber Company, NH*
- *Jonathan Thompson, Senior Ecologist, Harvard Forest, MA*
- *Leigh Whelpton, Program Director, Conservation Finance Network at Island Press, DC*
- *Ethan Winter, New York Conservation Manager, The Land Trust Alliance, NY*

The workshop agenda and the following chapters of this background paper are structured around the following topics:

- What are the implications of a changing climate for the science behind the stewardship of conserved lands?
    - ***Chapter 1:*** How might land trusts think about protecting the habitat values for which the land was originally conserved in the face of a changing climate?
    - ***Chapter 2:*** What are we learning about stewarding conserved land to maximize climate benefits, including both reducing greenhouse gasses (storage, emission reductions, etc.) and adapting to changing weather patterns (flooding, temperature, droughts, air quality, etc.)?
- What major new sources of ***funding*** are emerging around the services provided by conserved land in the face of a changing climate?
    - ***Chapter 3:*** How are the markets for the carbon storage and other mitigation benefits, (such as for water), from conserved lands evolving, both regulatory and voluntary?
    - ***Chapter 4:*** How is the funding for more resilient cities being used to expand investments in "natural" or "green" infrastructure (for water, temperature, etc.)?

This background paper is not intended to provide an exhaustive treatment of these topics. Rather, it is designed to offer attendees from many different backgrounds an introduction to some of the key concepts to help inform the workshop.

Summary of the Major Themes and Areas for Action

Bradford S. Gentry
Yale School of Forestry & Environmental Studies

The purpose of the 2016 Berkley Workshop was to explore some of the ways that land conservation groups might best respond to our changing climate, with particular emphasis on the science and finance guiding and enabling the stewardship of natural areas.

Among the major themes raised were the following:

- While ***increasing numbers of land trusts are incorporating the changing climate into their work,*** important issues arise around how useful traditional tools will be, as well as whether many land trusts have the capacity to engage in the more active management of conserved lands that is likely to be required.
- There are ***many ways that the stewardship of conserved lands may help address aspects of climate change,*** from storing carbon to mitigating flooding or heat waves. Capturing those benefits will require more systematic efforts to demonstrate that natural areas can provide those services in ways that fit infrastructure owners' and investors' decision-making contexts and criteria.
- ***Sources of funding for conservation projects with climate benefits continue to expand*** in number and quantity. However, the site specificity of many such projects raises real questions about how the volume of replicable investment opportunities that large investors are seeking can best be generated from such projects.
- In addition to science and finance, the participants felt it was ***also critically important to engage on the social aspects of these topics***—in particular, the need to expand the range of human communities that benefit from the climate and other services provided by conserved lands. Meeting this need will require new collaborations among conservation organizations and others working on topics from renewable energy to climate justice.

The rest of this chapter provides a bit more detail on these wide-ranging discussions, along with the participants' ideas for both action and future research.

There are real opportunities for natural areas to help address climate issues—and possibly to do so in ways that connect with other pressing social issues.

As described in more detail in Chapters 1 and 2 below, there is a growing awareness of the many ways that conserved lands may help address our changing climate. Natural areas store carbon, which helps to reduce/mitigate overall emissions. They can also help store water, manage flooding, and reduce temperatures—better enabling human communities to adapt to changing weather patterns.

Natural areas often provide these benefits at a lower cost than more traditional "engineered" solutions. As a result, (and as described in Chapters 3 and 4), growing numbers of funders—from cities to private equity managers—are looking at ways that they might invest in natural areas as part of their "infrastructure" portfolios.

"Land is not a side event in the climate arena, but a key part of the response."

— Andrew Bowman, Land Trust Alliance

With over 55 million acres of U.S. land now under their stewardship, land trusts are increasingly grappling with the question of how best to manage those lands in the face of a changing climate, as well as how best to finance those efforts.

The Climate Solution Set

According to Lara Hansen and the work at EcoAdapt, natural areas can be part of the "climate solution set" by focusing on the following activities:

1) Maintaining at least some habitat function in the face of a changing climate, by protecting refugia, genetic diversity, connectivity, topographic gradients, riparian zones, and forest cover.
2) Enhancing the ability of human communities to adapt, by capturing the opportunities natural areas offer to improve water and air quality, store water, mitigate flooding, improve health, and provide food, shelter, and energy.
3) Supporting the expansion of renewable energy through land use planning that identifies areas for protection, as well as for development.

For more information, visit:

http://ecoadapt.org/

At the same time, the US faces a wide range of social unrest—from inequality, to violence, health, politics and other pressing issues. Several workshop participants also pointed out how valuable access to natural areas can be in these troubled times—from the power of Outdoor Afro's "healing walks" (http://www.outdoorafro.com/), to the City Project's work to expand access to urban parks as safe places for kids to play (http://www.cityprojectca.org/), to the increasing numbers of land trusts expanding their efforts to meet the needs of their communities through their "community conservation" programs (http://www.landtrustalliance.org/topics/community-conservation).

"What is the science of justice – who benefits, who gets left behind?"

— Robert Garcia, The City Project

As a result, much of the workshop was spent exploring how best to make the most of these opportunities to have natural areas play both an increasingly important role in addressing climate change, as well as pressing social issues.

Capturing these opportunities is likely to require many land trusts to change how they work—from goals, to tools, expertise, locations and partners—as well as to navigate a wide range of uncertainties.

While the wide variety of organizations working on "land conservation" across the U.S. makes it difficult to generalize, there are some features that many of these organizations appear to share:

- Protecting particular animal or plant species by keeping people out of their habitats is a key goal;
- Donated conservation easements are a major tool for their land protection strategies;
- Expertise in acquiring rights to land and passive stewardship of those rights are among their key organizational capacities, (plus charitable fundraising);
- Suburban and rural areas are the places where most of their work is done; and
- Other conservation-focused organizations are their primary partners in larger projects.

All of these features have led to great gains in the amount of land conserved across the U.S.—as well as to significant climate benefits by preventing the development of those parcels.

At the same time, more is required—both to contribute meaningfully to addressing the scale of the challenges posed by climate change, as well as to do so in ways that also help address our pressing social issues. Some of the implications of this need to do more include the following:

Goals — Many land trusts will need to consider how to add to their existing goals, for example by moving from:

- Focusing primarily on individual species, to larger ecosystem structures and functions;
- Protecting static landscapes, ("keep the land as it is forever"), to changing habitats/landscapes; and
- Concentrating on non-human species, to adding habitat protection for humans as well – particularly our most vulnerable communities.

"Our 'healthy people/healthy places' work means that we are striving to do land conservation in ways in which the neighboring communities really do matter."

– Jay Espy, Elmina B. Sewall Foundation

***Tools* –** Many land trusts will need to explore moving beyond primarily accepting donated conservation easements to more participation in:

- Active selection and management of conserved lands to increase their climate benefits.

"Only six of the 269 conservation easements we studied mentioned climate change – and that was mostly in the form of a release of liability."

– Mary Scoonover, Resources Legacy Fund

- Landscape scale planning and the negotiation of standards for or the regulation of development/land management, such as:
  - Where should "good" development go – particularly cleaner energy facilities?
  - What should "good" forest carbon storage or green infrastructure projects include?

In California, large-scale solar facilities are widely seen as necessary to meet the state's climate targets. At the same time, such facilities can have huge impacts on the areas in which they are sited and the species that live there. According to Mary Scoonover of the Resources Legacy Fund, more attention needs to be paid to identifying both priority protection and development areas.

- Assembling deals around co-benefits, (flood control, temperature reduction and increased recreation), and layered financing, (public, philanthropic and for-profit).

"Resilience is likely not accurately priced into real estate investing because real estate is insured at the portfolio level – to really understand the risks one needs to evaluate each individual property."

– Hilary Irby, Morgan Stanley

- Aggregating deals involving many smaller parcels into attractive public or private investment opportunities at scale.

Organizational Capacities – Many land trusts will need to consider whether and, if so, how best to move from their more passive approach to easement monitoring and focus on charitable fundraising, to more active participation in the design, financing and management of projects and policies/standards to provide climate and social benefits at scale, such as:

- Design and construction of natural infrastructure installations (bioswales, rain gardens, etc.), forest carbon management plans, (harvest areas, frequencies, etc.), or similar projects.
- Financial engineering across the "layers" of finance that are increasingly being assembled.
- Community organizing to ensure that projects reflect and are designed to meet the needs of affected communities.
- Policy engagement around the types of land use/management standards and regulations noted above.
- Ballot measures to help provide funding for regional adaptation and mitigation actions (such as those in the San Francisco Bay Area).

A key part of this process will be recognizing and capturing the value offered by the huge variety of land trusts across the country—from all-volunteer, extremely local groups, to those with many staff and a global reach. That full range of contacts, credibility, and expertise are going to be needed across the wide variety of locations where these efforts need to be made.

"Don't confine these discussions to the coasts – find ways to engage on these topics with folks from across the US."

– Rick Huffines, Tennessee River Gorge Trust

Places – Much of this work remains to be done in the wilderness, rural, and suburban areas where land trusts have traditionally focused their efforts. At the same time, increasing attention is being paid to the benefits natural areas provide to cities—both within their borders (flood management, heat reduction, places to play/relax, etc.), as well as parts of more resilient supply chains, (water quality and quantity, food, building materials, etc.). Given the pattern of increasing urbanization, as well as this conceptual integration of natural areas and the services they provide into cities and their regional infrastructure, connecting the efforts of land trusts with groups in the cities is of increasing importance.

Partners – Many other organizations have been working on climate change for a long time. Many other groups have been working to address social issues in the U.S. for a long time. As more of these organizations see the opportunities for natural areas to help them achieve their own goals, land trusts have a huge opportunity to partner with them. Conservation organizations need to continue to reach out, listen, and build bridges with organizations whose work might benefit from increased access to natural areas.

Navigating Uncertainties —As land trusts enter these domains, there are many areas of uncertainty that they will need to navigate, including the following:

- What are the likely impacts and timing of our changing climate on the planet as a whole and on individual natural areas, as well as what are the likely effects of natural and human responses?
- Whether climate impacts on protected lands will undermine the original conservation values for which properties were acquired such that they can no longer fulfill their original purposes of conservation, and
- What the most appropriate balance between managing to retain original conservation values, encouraging system adaptation towards new conservation values, or allowing properties to evolve without human interference in the face of intense degrees of change may be.

Uncertainty and Climate Impacts

As pointed out by John Thompson from the Harvard Forest, there are huge regional differences in how our changing climate is manifesting itself. For example, in California and Oregon, it is becoming harder and harder to keep forests as forests, due to severe droughts, increasing fires, decreasing rates of forest recovery, and a biome shift to shrublands. In contrast, in the Northeast, there appear to be fewer direct threats to forests from the changing climate, but many indirect ones, such as pests, pathogens, and increased development

In addition, several participants noted that while huge changes are happening in the oceans – rising sea levels, increasing temperature and acidity—the impacts of those changes on terrestrial systems are not well understood.

For more information, visit:

http://harvardforest.fas.harvard.edu/other-tags/climate-change

- What is the likely performance of natural areas as tools to help address climate and social issues, as well as what are the risks of doing so, including:
  - The need more actively to monitor and assess the performance of "natural infrastructure" against the problems to be addressed
  - As well as to bring the performance and cost data into the decision contexts of infrastructure investors
  - So that natural areas can compete with traditional "grey" infrastructure where they are more cost-effective.

"The science of conservation biology is way ahead of that supporting investments in green infrastructure."

— Chris Larson, New Island Capital

- How best to measure and communicate the co-benefits natural areas often provide—particularly as part of efforts to layer financing by monetizing as many benefits as possible?

"We need to make the concept of using nature to help address climate impacts more accessible to the investment community."

— Hilary Irby, Morgan Stanley

- How best to address the displacement of lower income residents that often occurs as the amount of public greenspace in a neighborhood increases?
- How to find acceptable allocations of benefits and burdens in efforts to address climate issues—such as the debates around California's forest offset program (see box below)?

California's Forest Carbon Offsets Program – Environmental, Economic and Social Uncertainties Wrapped Together

California has one of the most robust programs allowing emitters of greenhouse gases to meet a portion of their emission reduction requirements by purchasing forest carbon offsets that meet certain regulatory standards—see: https://www.arb.ca.gov/cc/capandtrade/offsets/offsets.htm.

While this system has generated funding for forest conservation efforts from Maine to California, as well as involved a wide range of landowners (such as land trusts, tribal nations and timber investment management organizations), its future faces a wide range of uncertainties, such as:

1) Environmental: Are the regulatory standards sufficient to ensure that forest carbon offset projects are delivering the anticipated emission reductions?

2) Economic: For how long will the current standards be in place, i.e. how much certainty is there for potential future investors in forest carbon projects?

3) Social: Are the benefits and burdens of California's forest carbon offset program equitably shared – particularly for those living near major emitters in California or in forests in developing countries – and how will those questions be addressed during the review of the program going forward?

Getting one's arms around these and other, related areas of uncertainty, goes beyond the range of topics usually considered by a land trust in its traditional activities, but is none-the-less crucial. As noted by Dylan Jenkins, from Finite Carbon: "As a white, male forester, the social issues raised by carbon project development have challenged me – diversifying my contacts as I pursue this work has likewise expanded my perspective and increased my sensitivity to issues beyond simple project economics."

- How best to expand work on these human-centered initiatives as part of a wider effort that also embraces protecting habitats for non-human species as part of intact ecosystems?

These efforts also offer powerful opportunities for land trusts' emerging work on "community conservation."

The Land Trust Alliance defines "community conservation" as: "us[ing] the strengths of the land trust to meet needs expressed by people in the community." Of the five examples provided on the Alliance's website, three are likely to have climate benefits as well, from the expansion of tree canopy and the reduction of impervious services in parks and trails (flood management and temperature reduction).

"How do we increase human well-being through land conservation?"

– Jen Molnar, TNC

Such opportunities mesh powerfully with the workshop session on how land conservation might help address not only climate, but also pressing social issues – particularly in light of the shootings that had occurred just before the gathering. Those tragedies, combined with other deep divisions in U.S. society, make it clear that we need to weave a new social contract if we are to have any hope of either reducing or adapting to the impacts of climate change.

"The land conservation community has a huge opportunity to link values across a wider range of communities – we need to be better bridge builders."

– Rue Mapp, Outdoor Afro

The encouraging take-away from the workshop was that natural areas can help do so in so many ways – by creating great opportunities for land trusts to contribute their land, science and financial assets to partnerships with organizations pursuing:

- Improved mental and physical health, as well as community cohesion, through increasing access to natural areas
- Temperature reductions in cities by expanding green spaces/parks
- Better water management by using natural areas to clean and store water, as well as help control floods
- Capturing carbon in these natural systems and keeping it there by stewarding/ managing it for carbon storage
- Assisting in the deployment of more clean energy facilities, by helping to inform and navigate siting issues – including on some conserved lands

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"Watershed associations make progress dirt road by dirt road."

Chris Larson, New Island Capital

Such efforts should also attract funding from sources not usually used for protecting/restoring natural areas, as well as engage new beneficiaries across a range of communities—particularly for and with those people who are most vulnerable to the impacts of climate change. This can start in the locations where individual land trusts work and connect through the Alliance for even wider impacts.

It is important to use well the privilege that the private land conservation community has enjoyed to make progress on both climate and inequality issues—since, as the Pope and other religious leaders have noted, ultimately, they are one issue.

"We need to bring better justice to our work, to see what we have traditionally dismissed."

– Marc Smiley, Solid Ground Consulting

"Should more land trust people volunteer to work with community development organizations?"

– Avery Anderson Sponholtz, Impairative

Many different areas for both action and further research were noted by the participants.

During the final session of the workshop, participants were asked to describe actions they were planning to take as a result of the discussions, as well as any topics on which they thought further research would be helpful.

As for the actions they were planning to take, they included the following:

- Bringing the opportunities to link climate change, social justice and land conservation to the funders networks in which they participate
- Surveying the sites over which their organization has control to see if any are suitable for solar, wind, or other renewable energy projects
- Finding better ways to make the business case for using natural areas to help address climate and related issues as part of infrastructure planning and finance—particularly for cities, utilities, and companies managing large facilities

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"Using a musical analogy – we need to move from playing the notes that were written in the past, to performing improvisational jazz as we adjust to the future …"

— Lara Hansen, EcoAdapt

- Reevaluating the criteria used to evaluate proposals for funding conservation-related projects to ensure that they adequately reflect opportunities in urban areas
- Reaching out to environmental justice advocates to understand better their concerns about forest carbon offset projects and to explore possible ways forward
- Experimenting with new investment products to meet the growing investor appetite for opportunities in physical assets
- Becoming more actively involved in policy change—from energy siting, to new conservation tools and new infrastructure investments
- Doubling down on climate change education in communities of color
- Exploring opportunities for their land trusts to offer "healing walks"
- Taking ideas from the discussions and submitting them as suggestions for sessions during the 2017 National Adaptation Forum (http://www.nationaladaptationforum.org/)
- Writing about the need to think and act regionally around cities and their supply chains, particularly their connections to surrounding rural areas

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"Everyone here was hopeful—which was inspiring, as it is so easy to despair and withdraw."

— Chris Larson, New Island Capital

As for areas for further research, the following questions were identified:

- What experiments/data collection should be conducted to help support the climate-related services that natural areas can provide?
- How might the research results from conservation biology and ecological economics be most useful to efforts to design and implement natural infrastructure projects?
- How is investment capital flowing in these arenas and how might we use it to benefit more communities?
- How should the economic development benefits of land protection be captured and used in program development?
- How should gentrification/displacement issues best be addressed as access to natural areas is improved?
- How is social capital formed? How can disengaged/disconnected communities form it? How can doing so help them address climate vulnerabilities, including with natural infrastructure?
- How should the linkages between land conservation and addressing climate change best be made accessible and useful to non-specialist audiences?
- How should we define the metrics of success for adaptation efforts?

"I do worry that we are fiddling while the planet is burning – can we make progress fast enough?"

– *Judy Anderson, Community Conservation*

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1. Habitat Stewardship with Climate Change in Mind

Shelly Clark, Colin Kelly, Joshua Morse
Yale School of Forestry & Environmental Studies

"How might land trusts think about protecting the habitat values for which the land was originally conserved in the face of a changing climate?"

Conservation of habitat—whether wetlands preserved solely for their ecological value, agricultural fields protected to ensure availability of a crucial element of "human habitat," or working forests straddling both extremes—has historically centered around a promise of perpetuity. Land trusts at all scales promise to take on both the legal commitment to protect habitat from development, and the technical one to steward that habitat according to the conservation values for which it was protected, forever.

This perpetual stewardship commitment is uniquely threatened by climate change. While the consequences of climate change for land trusts have been explored with regards to acquisition strategy, discussion of the stewardship implications of projected climate change impacts on a wide range of habitat types remains nascent. This chapter aims to help advance that conversation.

Although projecting climate change impacts at the regional scale relevant to most land trusts is fraught with uncertainty (Rawlins et al. 2012), climate science offers predictions of larger scale trends with concrete implications that are relevant to habitat management. Research on anticipated changes in thermal habitat in the northeastern U.S. suggest a shift from suitability for northern hardwood forests towards transitional species like oak and hickory (Tobin et al. 2015, Iverson et al. 2008), although how changing habitat conditions will interact with extreme weather and the slow migration speed of most tree species remains uncertain (J. Thompson, L. Rustad, personal communication 2016). Warming temperatures across the continent are expected to alter the thermal habitat of a wide range of wetland systems, impacting their suitability for temperature-sensitive sport fish (Lane et al. 2013; Moyle et al. 2013). Changing patterns of precipitation and temperature will also impact agricultural suitability in many regions (California Natural Resource Agency 2009).

Climate change is not a novel topic in conservation, but most work on its implications for land trusts to date has focused on acquisition strategy. The Nature Conservancy's terrestrial resilience science (Anderson et al. 2012) is a prime example of this focus. However, as more land trusts shift their attention from acquiring new lands to the management of their present holdings (B. Gentry, personal communication, 2016), stewardship departments will be challenged to adapt to changing conditions. Whether by seeking to retain original conservation values through restoration, bolstering underlying 'resilience' through applications of new conservation paradigms, or embracing and encouraging system change outright, the land conservation community needs to turn its attention to strategies for stewardship in a changing world.

To advance the conversation surrounding habitat stewardship with climate change in mind, this report uses a case approach centering on three habitat types: working forests, wetlands, and agricultural systems. In each case, we consider: 1) what science is telling us about the likely changes and conditions that habitat managers will face in the coming decades, 2) some of the strategies being applied by organizations leading the way with regards to stewardship with climate change in mind, and 3) questions raised by—and opportunities emerging from—the intersection of habitat management and climate change. Key concerns relevant to the stewardship community at large, and to strategists incorporating stewardship into planning efforts at an organization-wide rather than departmental scale, are summarized in a final concluding section.

1.1 Working Forests

Working forests are the site of a diverse range of stewardship goals in the land conservation community, from wildlife habitat maintenance and improvement to timber production. In part because these goals can often be brought into alignment through thoughtful management, conservation-minded forest stewards have a wealth of resources at their disposal to inform the management of their woods under present conditions. However, while recent climate science suggests that substantial changes—with implications for timber production and wildlife habitat—are in store for North America's forests, management strategies that balance current conservation needs with possible future conditions remain largely theoretical.

1.1.1 Science

Although climate science is an ever-evolving field, strong evidence suggests that forest structure in North America will be disrupted by changing precipitation patterns and warming temperatures. Perhaps the best-researched example of climate impacts on forest structure lies in the boreal forest, which is predicted to experience northward migration, major dieback in its present core range, and species shifts (Scheffer et al. 2012; Kelly et al. 2013; Gauthier et al. 2015). The beginnings of species loss and forest die-off driven by a warming climate are already visible in the Canadian boreal, characterized by declining abundance of indicator species like moose and lynx, and unprecedented loss of key tree species such as lodgepole pine (Robbins 2015). The intensity of these trends moving forward remains difficult to pinpoint (Robbins 2015), but it is thought that the boreal forests face a biome-wide tipping point within the century (Lenton et al. 2008).

Although currently less pronounced, more temperate North American forests are also expected to see climate change impacts, and are projected to undergo species loss and range shifts as well. The most visible expression of this trend in the eastern U.S. today is the fast-paced decline of eastern hemlock—a major component of many mature forests—to the invasive wooly adelgid insect, whose northward advance is being aided by a warming climate (Paradis et al. 2007). Moving forward, it is expected that changing climatic conditions will favor other invasive species, pests, and pathogens (Peterson et al. 2014), increasing the already harmful impact of these forces on temperate forests (Dukes et al. 2008).

Also anticipated are the northward advance of transitional oak-hickory forests across New England (Tobin et al. 2015), and the expansion of birch-beech-maple in the northern forests at large (Shifley & Moser 2016). Such shifts in forest community are thought to be driven by changing thermal habitat suitability, a line of research pioneered by the U.S. Forest Service (Iverson et al. 2008).

However, the nuances of tree species migration in response to warming temperatures are the subject of considerable debate. The speed of thermal habitat change will likely far outpace the migration speed of most tree species (Aitken et al. 2008). Thus, some researchers expect that tree community structure and distribution will remain largely unchanged in the northeast through the 21st century (J. Thompson, personal communication, 2016). Others suggest that community restructuring will initially play out in early and mid-successional species with high population turnover rates, or that changes in abundance of certain species within their current ranges may be a more pronounced climate change effect (Canham & Thomas 2010). Collectively, this body of research suggests that while the regional suitability of forest habitat for the species presently in residence will change within the century, the time-frame at which this shift will be reflected in community restructuring remains uncertain.

The Trust for Public Land: Parks for People

While the scientific community at large debates the magnitude and extent of forest community shifts under climate change, researchers at Hubbard Brook – New Hampshire's venerable northern forests and watershed research station – are considering forest health and climate change from another angle. Rather than looking at climate change as a shift from baseline, Hubbard Brook scientists are conducting a series of field experiments that assume a warmer and wetter baseline, and consider the forest health impacts of extreme weather under this new regimen (Rustad & Campbell 2012). Lindsey Rustad, a lead investigator on a series of ice-storm field studies, speculates that warming temperatures and extreme weather could interact to create environments less well suited to northern hardwoods like sugar maple, but also challenging to transitional hardwoods like red oak. While warmer temperatures in northern New England are generally viewed as favorable to red oak, this more heat-tolerant species may be poorly adapted for the ice storms of New Hampshire, which are projected to increase in frequency and intensity under climate change, right alongside a general warming of the region (Rustad & Campbell 2012). Rustad notes that land managers are increasingly conscious and concerned about the implications of extreme weather over a climate-change baseline, and hopes that the scientific community will be able to provide concrete management recommendations as our understanding of this sort of interaction grows clearer.

For more information, visit:

http://www.hubbardbrook.org/research/climate/Rustad_12.shtml

1.1.2 Stewardship Strategies

Despite the current and anticipated changes to forest structure and health described above, the conservation community at large remains leery of engaging in forest stewardship that is deeply rooted in the scenarios predicted by climate science – and for compelling reasons.

Among forest managers focused on habitat conservation, a common concern about proactive climate-smart management is that the science of climate change is constantly being revised and updated. For stewards responsible in perpetuity for the management of forestland, the risks of engaging in aggressive proactive management based on projections that may shift is high.

Generally, this hesitance has led to adherence to management for mixed age class woods and species diversity – tried and true methods in sustainable forestry which feel to many in the stewardship community like relatively safe management options. However, in certain cases, often when climate change-related impacts to forest health are already being keenly felt, some conservation organizations have begun to act more aggressively. The box below illustrates one such case.

Climate Change & The Next-Generation North Woods

The Northern Institute of Applied Climate Science is partnering with local and national land trusts across the eastern U.S. to provide forest management prescriptions that take climate change into account. Headed up by The Nature Conservancy's Minnesota branch, a partnership of interest groups in the Great Lakes region's North Woods are using a climate change response framework to guide silviculture on 2,000 acres of a birch and conifer forest. Working off of projections indicating the decline of conifer and birch species in the area as climate change intensifies, the partnership is planting a diverse mix of native species with greater tolerance to warm temperatures, shifting moisture levels, and fire regimens. After planting, ongoing monitoring will help gauge the success of the warmth-tolerant seedlings, and inform future planting projects in the area. This work combines the best elements of both the conservative, tried-and-true strategy of managing for maximum diversity, and a more pioneering approach with elements of assisted species migration. By operating in the sweet spot between old and new, conservation partners in Minnesota offer a compelling template for regionally focused stewardship with climate change in mind.

For more information, visit:

http://www.forestadaptation.org/node/216

http://www.nrs.fs.fed.us/niacs/

Forest managers focusing on timber production rather than or in addition to wildlife habitat management also express hesitation to manage proactively with regards to climate change, but for economic rather than strictly ecological reasons. Among timber investment and management organizations (TIMOs), which own and steward large holdings, often under easement, the nature of timber investment presently discourages aggressive, proactive climate-smart management. Many TIMO landowners rarely hold properties for longer than a decade or two…a time frame too brief to justify up front and forward-looking management driven by projected species shifts, the exact timing of which remain uncertain. In the words of one New England TIMO executive, "I don't know of anyone who is culling sugar maple and managing for oak regeneration just yet".

Lyme Timber and the Climate Smart Learning Network

Although few TIMOs see an incentive to manage for different timber species, large landowners are beginning to incorporate climate change into their broader forestry practices. Having seen the impacts of several sever storms – including Hurricane Irene – on their networks of woods roads, the Lyme Timber Company began to consider how to manage their infrastructure in a changing world. In their search for answers, Lyme turned to Manomet Center for Conservation Science's new program, the Climate Smart Learning Network (CSLN). CSLN is a new initiative that is helping to connect land managers with science and expertise that they can act upon in the face of climate change. In the case of Lyme Timber, CSNL provided the data to support a management case for the installation of larger culverts along woods roads, in anticipation of more intense precipitation as New England gets warmer and wetter (The Forestry Source 2016). After their success with Lyme, CSLN went national, and now supports industrial and private landowners responsible for managing over 15 million acres with timely and actionable science to inform management in the face of climate change.

For more information, visit:

http://climatesmartnetwork.org/

http://www.lymetimber.com/

1.1.3 Implications

Perhaps the main lesson from current efforts to steward forestland with climate change in mind is that the challenge of justifying proactive management when the science continues to develop and the economic systems that drive management are anchored to a relatively short time frame is a significant one. However, the realities of species loss and community change in North American forests are already beginning to play out, despite our imperfect handle on the science of climate change and narrow economic horizons. Thus, the key task facing forest stewards in the conservation community is finding the opportunities for scientifically sound management that is economically feasible and promotes robustness in the face of climate change without making drastic changes to the health and value of the current forest.

Although this challenge may seem like a classic case of "easier said than done," this short review offers some insight into paths forward. Forest managers in both the land trust and TIMO communities cite the appeal of managing in response to forest health trends that are playing out in the present, such as fast-moving biological invasions and the advances of pests and pathogens in a warmer world. In certain cases like the loss of eastern hemlock to the northward advance of woolly adelgid, forest stewards are faced with a management challenge which is playing out today but which will surely worsen as climate change intensifies. Such cases present an opportunity to manage with the long-term implications of climate change in mind, but also to make progress towards near term stewardship goals

Management with Hemlock Woolly Adelgid in Mind

Hemlock mortality at the proverbial hands of woolly adelgid presents an interesting conundrum for managers. Eastern hemlock are of marginal commercial value, but at the same time, have considerable ecological significance, making management desirable but difficult to finance. A range of different strategies are being employed in response to the woolly adelgid by landowners and conservation interests of different scales.

As a large landowner invested in the wellbeing of hemlock woods in the Great Smoky Mountains National Park for predominantly ecological reasons, the Park Service is actively fighting to limit the speed and intensity of woolly adelgid infestations. By using a combination of synthetic insecticides and organic fungal agents alongside introduced predatory beetles, the Park Service is working to retain ecologically significant hemlock stands with some success.

While large-scale, systemic management shows some promise, the individual landowner or small land trust is unlikely to have the incentive or resources to aggressively combat woolly adelgid with combined synthetic, fungal, and predator treatments. At smaller scales, Harvard Forest biologists recommend avoiding both aggressive control measures and the tempting option of preemptive salvage cuts, noting that selective thinning of unhealthy trees to prolong stand survival is a more desirable option. There is also considerable ecological merit in allowing infested trees to die standing, a process which gradually increases light levels in the understory over a 4-15 year period, facilitating regeneration of post-hemlock hardwood and conifer species as well as producing some beneficial habitat features such as snags and large woody debris.

For more information, visit:

http://na.fs.fed.us/fhp/hwa/

http://harvardforest.fas.harvard.edu/news/managing-hemlock-forests-threatened-hemlock-woolly-adelgid

https://www.nps.gov/grsm/learn/nature/hemlock-woolly-adelgid.htm

1.2 Agricultural Lands

According to the Land Trust Alliance's 2010 census, 61% of land trusts identified conservation of farmlands and ranchlands as "very important" or "extremely important" (LTA 2010). These lands are a priority for conservation because of their habitat value, but also because of their social, economic, aesthetic, and cultural value for people and communities.

Recent models suggest that climate change will alter the location, timing, and productivity of crop and livestock systems, and that by the middle of the century, these impacts will be increasingly negative on most crops and livestock (NCA 2014). This in turn could impact the profitability of any farm operations on conserved lands, and could also diminish the heritage value for which many agricultural lands were originally conserved. The habitat values that agricultural lands provide to wildlife could also be undermined either through changing biophysical conditions or changes in farming practices.

1.2.1 Science

There are a number of ways that climate change can impact conservation activities on agricultural lands. Some of these are positive – warmer climates may increase yields of certain crops, lessen the threat of costly freezing events, or enable planting of more valuable cultivars in new places (Wolfe et al. 2011). However, most impacts are predicted to be negative over the longer term. The U.S. National Climate Assessment (NCA 2014), which was based on extensive peer reviewed literature, states the evidence as incontrovertible. According to the NCA report:

"The literature strongly suggests that carbon dioxide, temperature, and precipitation affect livestock and crop production. Plants have an optimal temperature range to which they are adapted, and regional crop growth will be affected by shifts in that region's temperatures relative to each crop's optimal range. Large shifts in temperature can significantly affect seasonal biomass growth, while changes in the timing and intensity of extreme temperature effects are expected to negatively affect crop development during critical windows such as pollination. Crop production will also be affected by changing patterns of seasonal precipitation; extreme precipitation events are expected to occur more frequently and negatively affect production levels. Livestock production is directly affected by extreme temperature as the animal makes metabolic adjustments to cope with heat stress. Further, production costs in confined systems markedly increase when climate regulation is necessary."

California's Statewide Adaptation Strategy (California Natural Resource Agency 2009) points to even more impacts:

- "Drought is a central challenge, primarily in water scarce Western States. Some of the predicted impacts of changes in precipitation include: reduced supply reliability and legally mandated fallowing, increased fire risk to rangeland, increased erosion on dry and/or steep terrain, and changes in ozone and air quality. Heat also often increases the consumptive use of water through increased evapotranspiration, sometimes increasing yields, but also exacerbating drought.
- Heat waves, which are projected to become more frequent, can cause stresses that can lead to losses in quality and yield.

- Changes in winter chill hours. Some crops benefit from warmer temperatures and longer growing seasons, but others, including many cultivars of fruits, grapes and almonds require cold temperatures in the winter to achieve optimal springtime growth.
- Sea level rise can cause saltwater intrusion onto soils of coastal farms, or even outright flooding of low-lying farmlands. This can cause damaging increases in soil salinity, as well as surface water and groundwater supplies.
- Flooding produced by heavy rainfall events can be damaging to crops, especially during the planting season.
- New weed invasions/expanded ranges of existing weeds can reduce yields and increase eradication costs (and potentially pesticide runoff if more is required).
- New disease & pest invasions/expanded ranges of existing diseases & pests.
- Increased animal vulnerability to disease.
- Increased mortality of animals and less production from animals with higher temperatures."

Agricultural land also provides important habitats for a multitude of birds, mammals and other animals. According to Mass Audubon, "most grassland birds use hayfields, meadows, and pastures for breeding while many other birds nest nearby and use crop fields and open areas for hunting and foraging. Some species nest along weedy borders and shrubby edges of fields and rely on open fields for feeding on seeds and insects" (Mass Audubon 2016).

Changes in where and how agriculture is practiced will impact these habitat values. In the arid west, forced fallowing of irrigated agricultural lands could lead to virtual desertification as the water necessary for life to flourish is removed (NRC 2012). Another risk is that some species that may be disappearing from farmlands as a result of climate change are also essential pollinators, or that cues used by plant-pollinator pairs become out of synch (NASA n.d.).

1.2.2 Stewardship Strategies

Given the many different types of climate impacts, as well as the many different types of agricultural land, stewardship strategies for conserved agricultural land are varied. It can be valuable to "look south" to see what types of challenges and opportunities could be moving northward as the climate continues to warm, but that strategy on its own is not adequate, as there are additional impacts and uncertainties related to how climate change will impact agricultural lands (Wolfe et al, 2011). Table 1 provides further detail using New York state as a case study.

Fortunately, many of the agricultural practices that improve resilience to climate change are the same ones that have been used for a long time to improve soil health, drought resilience and reduce runoff from extreme weather events. For example, cover crops have the potential to provide multiple benefits in a cropping system. They prevent erosion, improve soil's physical and biological properties, supply nutrients, suppress weeds, improve the availability of soil water, and break pest cycles along with various other benefits. The species of cover crop selected along with its management determine the benefits and returns (NRCS n.d.). Another long acknowledged practice is avoiding soil compaction, which reduces surface water runoff, improves aeration while also increasing soil carbon storage (FAO 2012).

Funding to support these measures is available through a multitude of Farm Bill supported government programs.

Climate Factor	Climate Certainty	Associated Vulnerabilities/Opportunities	Certainty*	Timing	Adaptation Strategies	Adaptation Capacity
Increasing carbon dioxide	High	Variable plant response affecting growth, competitiveness, yield. Under optimum conditions, yield increases are possible. Some C_3 weeds will benefit more than crops and be more resistant to herbicides.	High, but large variation in effects depending on other environmental constraints to plant growth	Now	Minimize water, nutrient constraints to crop growth to take full advantage of any beneficial effects. Develop varieties that take advantage of the effect of increases of carbon dioxide concentrations. Increased weed control and new approaches to minimize chemical inputs.	Moderate
Warmer summers; longer growing seasons	High	*Crops and weeds* Opportunities to obtain higher yields with current crops and grow higher-yielding varieties and new crops. Eventual double-cropping opportunities. Weeds will grow faster and will have to be controlled for longer periods. Increased seasonal water and nutrient requirements.	Moderate to high	Now, with some effects occurring later this century	Cautiously explore new varieties, new crops; develop markets for new crops. Increased weed control and new approaches to minimize chemical inputs. Increased water and fertilizer applications.	High
		Insects More generations per season; shifts in species range.	Moderate to high	Now	Better regionally coordinated monitoring through integrated pest management. Increased pest control. Proactively develop new approaches to minimize chemical inputs.	Moderate
Increased frequency of summer heat stress	High	*Livestock (dairy)* Reduced milk production; reduced calving rates.	High	Serious by mid-century	Increase cooling capacity of existing dairy barns. Increase use of fans and sprinklers. Change feed rations. Provide plenty of water. Design new barns based on projected future heat loads.	Moderate to High
		Crops Could negatively affect yield or quality of many cool-season crops that currently dominate the agricultural economy, such as apple, potato, cabbage, and other cole crops.	High	Serious by mid-century	New heat-tolerant varieties when available. Change plant dates to avoid stress periods. Explore alternative crops.	Moderate to high
Warmer winters	High	*Crops* Could increase productivity or quality of some woody perennials (e.g., European wine grapes), while by mid to late century negatively affecting those adapted to current climate (e.g., Concord grape, some apple varieties). More winter cover crop options. Depending on variability of winter temperatures, can lead to increased freeze or frost damage of woody perennials	High	Now, with some effects occurring later in century	Explore new cash crops and varieities; explore new cover crop options.	High
					Better freeze and frost warning systems for farmers; new winter pruning strategies.	Moderate
		Insect and weed pests Increased spring populations of marginally overwintering insects. Northward range expansion of invasive weeds.	High	Now	Better regionally coordinated monitoring through integrated pest management. Increased pest control. Proactively develop new approaches to minimize chemical inputs.	Moderate
Increased frequency high rainfall, flooding	High	Delays in spring planting and harvest, negatively affecting market prices. Increased soil compaction, which increases vulnerability to future flooding and drought. Increased crop root disease, anoxia and reduced yields. Wash-off of applied chemicals.	High	Now	Increase soil organic matter for better drainage. Shift production to more highly drained soils. Install tile drains. Shift to flood-tolerant crops. Change plant dates to avoid wet periods. Increased disease control and new approaches to minimize chemical inputs.	Low to moderate; some options are expensive
Increased summer drought	Moderate	Reduced yields and crop losses, particularly for rain-fed agriculture. Inadequate irrigation capacity for some high-value crop growers.	Moderate to high	Mid to late century	Increase irrigation capacity. Shift to drought-tolerant varieties. New infrastructure for regional water supply.	Moderate, assuming capital available and economics warrant investment
Changes in hydrology, groundwater	Moderate	Dry streams or wells in drought years. Increased pumping costs from wells.	Moderate	Mid to late century	Deeper wells, new pumps.	Moderate
Frequency of extreme events	Low	Major crop and profit loss due to hail, extreme temperatures, flooding, or drought. Particularly devastating if extreme events occur in clusters.	Moderate to high	Unknown	New climate science research to determine current trends and develop early-warning systems for farmers.	Moderate
Increased seasonal variability	Low	Crop damage due to sudden changes, such as increased freeze damage of woody plants as a result of winter variability and loss of winter hardiness or premature leaf-out and frost damage.	Moderate	Now, but not clear if part of climate change	New climate science to determine relation to climate change and better predict variations.	Low
Changes in cloud cover and radiation	Low	Important factor affecting plant growth, yields and crop water use. Cloudy periods during critical development stages reduces yields.	High	Unknown	New climate science research to determine current trends and better model these factors.	Low to moderate

Image courtesy of NYSERDA, ClimAID Report (Wolfe et al. 2011):

http://www.nyserda.ny.gov/-/media/Files/Publications/Research/Environmental/EMEP/climaid/ClimAID-Agriculture.pdf

Strategies to use less water more efficiently are also well established in areas that have experienced frequent drought. Efficiency measures such as drip irrigation can reduce the amount of water that needs to be withdrawn from streams and aquifers, as well as minimizing impacts of agricultural runoff and soil salinity (Pacific Institute 2014). Water sharing agreements between cities and farmers can also increase urban drought resilience while keeping enough water on farms to sustain agricultural production. Colorado's new State Water Plan, for example, is promoting "alternative transfer mechanisms" such as rotational fallowing, interruptible supply agreements, water banks and water cooperatives (CWCB 2015). These drought mitigation strategies, some new and some long established, can help land trusts keep farm and ranch lands in production in the face of a changing climate.

Sometimes, however, agricultural lands will need to come out of cultivation. In an interview for Yale Climate Connections, Krista Magaw, executive director of the Tecumseh Land Trust in Yellow Springs, Ohio, reflected that "We don't try to be restrictive about the kind of agriculture that is conserved. But some areas will need to come out of cultivation, and we now include wording in our easement to reflect future changes, such as expanding a riparian corridor that crosses farmland" (Palmer 2015).

1.2.3 Implications

A key takeaway is that most of the measures that are currently promoted and funded through existing agricultural land and water conservation agencies and organizations are the same types of measures that can help adapt conserved farmlands to projected climate change impacts.

However, given that the droughts, floods and other impacts that these existing practices are designed to deal with are all expected to increase in severity and frequency, it is likely that these practices will need to be modified, scaled to new geographies and funded in a more significant and predictable way.

There are also problems related to uncertainty and immediacy—when and how should we implement adaptation measures when we are not certain of what the exact impacts will be and when exactly they will come? The science shows that climate change will have profound impacts on agriculture, but given the immediate challenges land trusts face as they confront suburban sprawl, high land prices, and aging farmers, climate change can seem like a more distant priority.

1.3 Wetlands [3]

For decades the conservation community has sought to protect wetlands for the wildlife, distinctive vegetation, rare and endangered species, and generally high biodiversity they support. Scientists also now recognize that the natural functions of wetlands serve human societies in numerous ways. Wetlands can improve the quality of downstream rivers and lakes, store floodwaters, buffer coastlines from storm surges, and serve as carbon sinks. Yet

3 Special thanks to Barbara Bedford for her assistance preparing the Science and Non-tidal Wetlands sections of this report.

over half the wetlands in the lower 48 states have been lost (USGS 2016). Consequently, conservation efforts and federal and state regulation of wetlands have slowed the loss of wetlands within the U.S. (Mitsch and Gosselink 2015).

However, as climate changes, wetlands will change, regardless of conservation status or regulation. The abundance and distribution of wetlands in the landscape are controlled by climate and hydrology as affected by regional and local geomorphology. By determining temperatures, precipitation, and winds, climate drives the hydrologic systems upon which wetlands are dependent. Regional and local hydrogeology controls the flows of surface and groundwater to wetlands, but the flows themselves are set by climate (Bedford 1996).

The land trust community and other conservation organizations now must confront the implications of climate change for wetlands and the services they provide to human societies. The decisions they make in terms of acquisition and management of wetlands in their portfolios, insofar as possible, should be made with climate change foremost in their minds.

1.3.1 Science

Essentially, wetlands are ecosystems whose characteristics are determined by "constant or recurrent, shallow inundation or saturation at or near the surface of the substrate" (NRC 1995). These characteristics necessarily include soils (hydric soils) and vegetation (hydrophytic vegetation) that develop in response to constant or recurrent, shallow inundation or saturation at or near the surface of the substrate. Thus, wetland hydrology controls all other properties of a wetland. Common types of wetlands include bogs, fens, marshes, and swamps but the variation within these general types is immense. Vernal pools, prairie potholes, bayous, and playas are all wetlands, as are sedge meadows and wet prairies.

The fundamental principles by which to assess wetland responses to climate change are well understood. The challenge for land trusts and other conservation organizations is applying these principles to particular wetlands in particular landscapes. The high diversity of wetland types and the many different landscapes and geological terrain in which they occur make simple application of general principles inappropriate. Land trust decisions about particular sites will need to be made on a case-by-case basis, always within the context of the watershed in which the wetland occurs. The implications of climate change for specific wetland types are detailed in the subsections below.

1.3.1.1. Tidal Wetlands

The clearest threat to tidal wetlands is sea level rise. Analysis of a global network of tide gauge records shows that sea level has been rising at the rate of about 0.6 inches per decade since 1900, or 6 inches over the past century (National Ocean Service 2016). Recent satellite data showed global sea level in 2014 to be 2.6 inches (67 mm) above the 1993 level, a rate well above the century-long record (Lindsey 2016). More rapidly melting glaciers and sea ice and thermal expansion of seawater as global mean temperatures rise are likely to increase rates of sea level rise.

Observed and predicted consequences for tidal wetlands include:

- Intrusion of saline water into previously freshwater tidal marshes, causing freshwater vegetation to be replaced by salt-adapted plant species or complete loss of vegetation; such changes already have occurred widely in wetlands of Chesapeake Bay, southern Lousiana, and the Florida Everglades;
- Flooding of uplands adjacent to tidal wetlands, if hardening of shorelines or other land uses do not prevent upslope migration of wetlands;
- Complete loss of wetlands due to permanent flooding by seawater, as has occurred extensively in Louisiana and Chesapeake Bay; and
- Loss of freshwater tidal wetlands, the more diverse of tidal wetlands, as saline water moves farther inland.

How extensive effects will be for a given area will depend on coastal topography and geomorphology both above high tide and below low tide. The shallower the slope of the land and immediate seabed, the more spatially extensive are effects likely to be. The higher the degree of development adjacent to wetlands, the more constricted wetlands will be in their ability to migrate upslope. Loss of wetlands within bays will depend on the shape of the bay and the width of its opening to the sea which constrains tidal inundation.

Detailed digital elevation maps showing probability of flooding with various levels of sea level rise are available for most coastal states (NOAA 2016)

1.3.1.2 Non-Tidal Wetlands

Because climate drives the entire hydrologic system on which wetlands depend, climate change will affect inland wetlands of all types. More variable and extreme precipitation events, along with warmer global temperatures, already have altered many inland wetlands. They will continue to do so as climate change accelerates.

Climate forecasts differ by region. For example, the U.S. Southwest is forecast to become hotter and drier, and the U.S. Northeast is forecast to experience more variable and extreme precipitation events along with generally warmer conditions leading to longer annual droughts. The 2014 U.S. National Climate Assessment reported findings by six regions within the contiguous 48 states, plus Alaska, Hawaii, and the coasts.

Within each region, wetlands differ by their hydrogeomorphology and setting within the landscape (Winter et al. 1998; Brinson 1993; Bedford 1996). These characteristics control water inputs and outputs from a wetland, and determine if precipitation, surface water, or ground water dominate inputs to a wetland. In turn, the proportion of water inputs from precipitation, surface water, and groundwater determine a wetland's hydrologic regime and water chemistry. Species composition and the ratio of wetland productivity to decomposition are a function of these two variables. Thus changes in these variables form the basis for predicting wetland response to climate change.

However, few land trusts and conservation organizations have the expertise to be specific about effects on any particular wetland. Wetlands support too many species of plants and animals to ever hope to understand how each individual species will respond to climate change. Rather, most scientists and management agencies recommend an approach that thinks in terms of groups of species, ecosystems and the broader landscape. For example, numerous studies have shown that amphibians (e.g., Brooks et al. 2009) and waterfowl (e.g., Johnson et al. 2005), groups highly dependent on wetlands are likely to be negatively affected by climate change. Managing at the ecosystem level means protecting sufficient land adjacent to wetlands that they can expand or contract as hydrology changes with climate. Thinking in terms of landscapes means thinking about protecting places in given landscapes where wetlands occur or might occur with climate change. It also means making decisions about which wetlands in a given landscape may be more resilient than others and expending resources on a limited subset rather than all wetlands.

1.3.2 Stewardship Strategies

All wetlands are embedded in watersheds and larger landscapes. Water, nutrients, pollutants, sediments, birds, mammals, amphibians, insects, other organisms, and seeds move within these landscapes and determine the characteristics of each wetland and adjoining lands. Human populations also move within landscapes and change land use patterns. Most human-dominated land uses (e.g., intensive agriculture, highways, commercial and residential development) affect wetlands, their plant and animal inhabitants, and their capacity to adapt to climate change. Wetlands and their inhabitants may have to reposition themselves in the landscape as climate changes. Climate-resilient conservation strategies for wetlands thus will need to be made within this larger context and explicitly consider how wetlands are connected to each other, as well as to other ecosystems within watersheds and landscapes.

Linking Wetlands and Uplands in Glaciated Landscapes

Wetlands do not exist as isolated ecosystems. They form the interface between open water and uplands in larger landscapes. Thinking about any conservation strategy must begin by thinking about their landscape context. Many waterfowl species, wading birds, and most amphibians move from wetland to upland and from wetland to wetland. Fish move from stream or lake to wetlands and back. Water flows to and from wetlands to streams and lakes.

The Finger Lakes Land Trust (FLLT) has maximized these linkages, and their resilience to climate change, by working to create what they call the "Emerald Necklace." This ambitious program works to connect 50,000 acres of existing conservation lands in an arc around Ithaca, NY. Connections are made through targeted purchases and easements supported by donors and grants. Most purchases and easements comprise a mosaic of wetlands, uplands, streams, and ponds across a landscape of diverse topography and soil type. Such topographic and ecological diversity provides the range of templates needed for organisms and ecosystems to adapt to climate change, moving as conditions change.

To learn more about the FLLT "Emerald Necklace," see:

http://www.fllt.org/land-purchase-expands-emerald-necklace-greenbelt-and-adds-to-existing-nature-preserve-in-tompkins-county/

As in forest and agricultural systems, some tried-and-true wetland stewardship techniques will remains crucial elements of management as climate change intensifies. Moving forward, land trusts should map and identify wetlands areas that are sensitive to climate change. Restoration of wetlands to their natural state tends to be the guiding long-term objective for wetland stewardship (Land Trust Alliance 2015). Traditional stewardship focuses such as habitat restoration—returning wetlands to their historical, natural state—and keeping wetland systems connected (Kusler 2016) are key strategies that will retain their value as land trusts adapt to climate change.

For coastal land trusts, keeping an eye on transitioning lands is an important new concern. As sea level rises, former agricultural and forested lands are becoming tidal wetlands. Strategies for aiding uplands transition into tidal wetlands include stopping the spread of invasives, removing dead trees, and planting a transition crop (Blackwater 2100). Invasive species, which threaten food webs, degrade habitats, and alter biodiversity in wetland environments by out-competing natives and creating monotype vegetation systems that erode more easily than diverse systems, are a particular concern to many conservationists (Maine DEP).

Setbacks can also be created to allow tidal wetlands to migrate (Kusler 2016). Aiding in the transition of uplands into tidal wetlands is also a theme of land trust management of marshes. Some of the most important habitat types to maintain for facilitated wetland migration are "low-lying, undeveloped uplands adjacent to coastal wetlands (beaches, mudflats, salt marshes, etc.) and undeveloped areas that serve as landscape scale habitat connections (especially riparian areas)" (Casco Bay 2010).

Predicting trends in water fluctuation is another challenge for wetland managers. Manipulating water levels in inland wetlands to prevent drying brought on by increased temperatures and low precipitation could be a solution to these fluctuations (Kusler 2016). Further, restoring wetland habitats could call for developing water level management infrastructure like dikes and pumps to emulate original wetland conditions in a changing climate (Great Lakes Commission 2014).

Connecting Stream Segments in Riverine Landscapes

Many wetlands occur along stream corridors where climate change will bring more extreme precipitation events more frequently to some regions (e.g., the U.S. Northeast), and more extended droughts to others (e.g., the American Southwest). If greatly enlarged episodic stream flows are not accommodated by current road and bridge infrastructure, high volume flows may erode streamside wetlands, eliminate potential future sites for wetlands, or deposit sediments so deep as to eliminate existing vegetation. Such extreme flows also may damage roadbeds and other community property.

The Adirondack Chapter of The Nature Conservancy (TNC) is addressing this challenge with an innovative strategy—working with highway departments and other partners to improve culvert design to benefit nature and people. Poor design blocks the passage of water and fish (e.g., brook trout) seeking the cool waters of groundwater-fed wetlands along the stream. It also increases the risk of flooding human communities and damaging roadbeds, as well as the risk of eroding wetlands or smothering them in river-born sediment.

To learn more about this multifaceted TNC strategy, including a "Climate Friendly Stream Crossings Toolkit" developed in collaboration with other organizations, see:

http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/newyork/climate-energy/new-york-culvert-inventory.xml

Some land trusts are turning to rolling easements to ensure protection of wetland ecosystems. A rolling easement is an enforceable expectation that a shoreline or human access along a shore can migrate inland. A rolling easement could come in the form of a law that prohibits shore protection or amends property rights to help allow wetlands, beaches, barrier islands, or access along the shore to move inland with the natural retreat of the shore (Great Lakes Commission 2014).

Looking Forward by Looking Backward:
Identifying Climate-resilient Ecosystems and Refugia

Scientists working in the field of paleoecology have learned how lakes and wetlands have changed with climate since the last glaciation, approximately 10,000 years ago. They also have identified wetlands that did not change with climate in any significant way, i.e., although they changed from one type of wetlands to another, they remained wetlands. In addition, they have identified what they call paleorefugia, wetland sites where many species found refuge to persist through climate change (Nekola 1999). Recently, limnologists have worked to identify climate-resilient lakes, lakes where species might survive climate change because of the physical and geological conditions responsible for the lakes' fundamental properties.

In the past few years, the Adirondack Chapter of The Nature Conservancy (TNC) has been engaged in characterizing climate-resilient features of freshwater lakes that provide habitat for lake trout. At the same time, they are assessing the lake's adjoining wetlands and its entire watershed to determine how these surrounding ecosystems may be central to maintaining the lake's resiliency. Future work could entail identifying climate-resilient wetlands and wetland refugia. Strong candidates include wetlands heavily dependent on groundwater inputs, which might be expected to buffer temperature increases and water level fluctuations in such wetlands.

To learn more, visit:

http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/newyork/climate-energy/adirondacks-lake-trout-studies.xml

1.3.3 Implications

Because of their lack of value in many human economies (as opposed to agricultural and timber lands), people have historically undervalued wetland environments. As such, management strategies for retaining these crucial habitats in the face of climate change are less well developed than those for agricultural or forest systems. However, the ecosystem services like coastal protection and water filtration that wetlands provide are invaluable in the context of climate change. Present and future land managers must look to wetlands not only for their innate ecological value, but also for the essential services they can provide to humans.

Looking ahead, coastal land trusts and land trusts in low-lying areas will be faced with wetland issues more frequently as sea levels rise and precipitation patterns become more varied. The key challenge facing wetland managers in the conservation community is understanding fluctuations in water levels and changes in shorelines. Obtaining parcels that will be a part of wetland transitions, understanding where new habitats will be for wildlife that are dependent on wetlands, and facilitating the movement of these systems should be stewardship priorities moving forward.

Opportunities to increase research into wetland management and to muster financial and technical support for this work should also be cultivated. Wetlands are valuable for the ecosystem services they provide, in addition to the habitat values they offer. As humans grapple with the onslaught of extreme weather conditions brought by climate change, wetlands should be part of the response. For example, municipalities can use wetlands as less expensive, natural protection from increased flooding instead of relying solely on often more expensive grey infrastructure. Coastal protection is another increasingly important role wetlands can play in the changing climate. These functions should be emphasized to attract both research and management dollars to help spur the development of new roles for wetlands going forward.

1.4 Conclusions

Across ecosystem types, the traditional conservation values that land trusts have stewarded for will be taxed and in some cases transformed by climate change. While climate change implications for forests, wetlands, and agricultural systems differ, some common themes emerge in reviewing the range of stewardship strategies being considered in each case.

1.4.1 Managing for Diversity

Most striking is the importance of stewarding for diversity, today and in the future. Already a central principle of wetland restoration work, diversified agriculture, and forest management for wildlife and timber, stewardship that increases the diversity of species and habitat niches on conservation land is the single most important strategy that conservation organizations can pursue to protect traditional conservation values in the face of climate change.

Inherent in this approach is the understanding that the particular species and community structures of a given conservation area are likely to change with time. Hemlock may be replaced by black birch as the predominant shade species keeping Appalachian streams cool, inland wetlands may become brackish as sea level rises, and crop suitability on agricultural lands may change with shifting plant hardiness zones.

For conservation organizations charged with stewarding a particular species or ecosystem type, such shifts may be difficult to accept. But, in the service of the broader goal of protecting functional wild and working landscapes and ecosystems, stewarding for the diversity today that will allow a smooth adaptation to the ecosystems of tomorrow will be essential. Such a change in perspective would be a significant shift for much of the land conservation community, and one which land stewards will have a key role in supporting, thanks to the strength of their experience of changing habitat conditions on the ground.

Looking Ahead to Indirect Climate Change Impacts on Conservation Land

For certain regions, some of the most profound climate impacts may not arise directly from the loss of forests, wetlands, or agricultural areas to warming weather and changing precipitation. Rather, a Harvard Forest study on land use trends in Massachusetts suggests that climate change may present management challenges that stem from indirect causes as well. Growing incentives for regional self-reliance might prompt increased forest clearing for agriculture and biomass fuel, fragmenting habitat, releasing carbon, and rendering forests more vulnerable to invasive species. Opportunistic development to accommodate families moving to the relatively clement interior of New England from warmer, drier, or more flood-prone regions could increase the spread of impervious surfaces across the landscape, exacerbating stormwater runoff issues already expected to increase with more intense precipitation. As the Rustad lab at Hubbard Brook (see Section 1.1) suggests, it is important to view climate change as a new baseline underlying ecological and social processes like extreme weather, population movement, and land use change, with the potential to heighten traditional threats to conservation habitat in addition to introducing novel ones.

For more information, visit:

http://harvardforest.fas.harvard.edu/changes-to-the-land.

1.4.2 Managing Under Uncertainty

Beyond broadly focused management for diversity, land trusts and conservation organizations working on a range of systems types also share a common Achilles heel as they consider stewardship with climate change in mind: the ever-shifting nature of the scientific dialogue surrounding location-specific climate change impacts. Uncertainty surrounding how particular ecological communities will respond to changing habitat zones, where new wetlands will emerge and what sort of wildlife they will support, and how to identify and retire agricultural lands that may eventually be unfit for cultivation remains a constant obstacle to taking decisive actions with long-term consequences. At its core, land conservation has been a conservative field concerned with maintaining things as they are rather than embracing change. Learning to manage with uncertainty, given the best available information and the best possible understanding of local community priorities and ecological limitations will be a crucial goal moving forward.

1.4.2.1 Looking Ahead Rather Than Looking Back

As land trusts increasingly prioritize diversity and learn to manage under uncertainty, they will find themselves—and may in fact already find themselves—stewarding as much in anticipation of the future as in veneration of the past. Practices like restoration ecology must shift from focusing on re-creating a specific past condition towards returning systems to the point of functionality, as measured by their ability to adapt to new and intensified stressors.

And, early 20th perspectives like the idea of conservation as "setting something aside" will need fully to give way to the recognition that our field is very much an investment in a single, dynamic social-ecological system which we inhabit.

In this review, we have seen cases where the sort of forward-looking paradigm called for in the previous paragraph is being applied successfully, such as the system function focused diversification plantings in the Minnesota Northwoods. We have also seen evidence of areas where old paradigms like the idea of conservation as the work of setting wild places apart from human systems still holds sway, to detrimental effect. Perhaps the best such example is the apparent lack of theory and strategy that has been developed for the efficient management of wetland systems in a changing world relative to forest and agricultural systems, which we believe stems from the fact that wetlands have not historically been seen as sources of direct benefit to society. Looking ahead, the conservation community needs to expand its vision of stewardship to rise to the challenges and opportunities of a future where climate change renders the distinctions between environment and society permeable, and where thoughtful and proactive management can ease the transitions facing both.

Possible Questions for Discussion

- Is there a clear point of distinction between managing for system function and abandoning old conservation values in response to changing conditions? Transitioning agricultural land no longer suited to production into wildlife reserve seems like a clear example, but what about repopulating a wetland with drought-tolerant plants in response to changing precipitation regiments? When should land trusts fight to retain original values, and when should they embrace change (and, how much change should they embrace)?
- Invasive species management: at what point do we need to give up on a native species threatened by overwhelming invasive species pressure or changing climate? Are the Park Service's efforts to protect eastern hemlock in the Great Smoky Mountains—ultimately likely a losing battle—worth it, or should we accept the decline of eastern hemlock and focus our management attention on helping whatever comes next thrive?
- How can easements be written to give land trusts the flexibility to adapt to climate change, especially in cases like agricultural land retirement and coastal migration? What role do stewardship departments have in helping to craft easements to make adaptive management possible under uncertain conditions? Rissman et al. 2015 offer a useful summary of the state of the conservation community's efforts to incorporate climate change adaptation and mitigation options into fixed easements.
- How can land trusts help the conservation community—and our society at large—recognize the value of stewarding traditional conservation lands for climate resilience? Can highlighting new, human-centric uses for traditional conservation values (Plumb 2016) be a part of the solution?

Some of the Organizations Doing Interesting Work on this Topic

Forests

- **Cary Institute of Ecosystem Studies** is a research hub in the Hudson River Valley, NY, with a focus on ecosystem function. Their research on climate change and invasive species is particularly useful. In this report, the Cary Institute contributed to our discussion of uncertainty regarding the nature of forest community response to changing thermal habitat.

  http://www.caryinstitute.org/what-we-do/climate-change

- **Climate Change Response Framework** is a useful collaboration between scientists, land managers, and landowners, which sponsors and reports on key lessons from climate adaptation work being done in forests around the northern and central US. TNC's tree planting work in the Minnesota northwoods is one of their focal projects.

  http://www.forestadaptation.org/

- **Harvard Forest** is a forest ecology and land conservation research station based in Petersham, MA, with particular expertise in long-term ecological monitoring and landscape conservation scenario mapping. Harvard Forest has excellent resources on Eastern hemlock and hemlock woolly adelgid.

  http://harvardforest.fas.harvard.edu/other-tags/climate-change

- **Hubbard Brook** is a leading northern woods research station, and home to a series of novel experiments on forest adaptation to climate change and extreme weather impacts.

  http://www.hubbardbrook.org/

- **Northern Institute of Applied Climate Science** is a forest service/private industry collaboration that conducts, sponsors, and promotes research on the management and carbon sequestration implications of climate change for the northern forests of the U.S.

  http://www.nrs.fs.fed.us/niacs/

- **USDA Climate Hubs** are a seven-center program of the USDA that provides an institutional home for research into climate impacts and adaptation/mitigation options for the U.S. by broad region (northeast, southwest, etc). Responsible for producing climate impact assessments for each region, which are excellent summaries of current climate change findings with relevance for working land owners.

  http://www.climatehubs.oce.usda.gov/

Agricultural Systems

- **American Farmlands Trust** works nation-wide to protect farmland, promote sound farming practices, and keep farmers on the land

  https://www.farmland.org/

- **Cornell Institute for Climate Change and Agriculture.** Serves as a focal point to facilitate research, education and outreach to help farmers in the Northeast become more resilient to extreme weather and climate variability.

  http://climateinstitute.cals.cornell.edu/

- **USDA Natural Resource Conservation Service (NRCS):**

  Pollinator Value of NRCS Plant Releases used in Conservation Plantings is a resource guide on the characteristics of 80 conservation forbs/wildflowers and legumes useful for improving pollinator habitat.

  http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/plantmaterials/technical/publications/?cid=stelprdb1

- **The NRCS Plant Materials Program** selects conservation plants and develops innovative planting technology to address today's natural resource challenges and maintain healthy and productive farms and ranches.

  http://www.nrcs.usda.gov/wps/portal/nrcs/site/plantmaterials/home/

- **The Environmental Quality Incentives Program** (EQIP) is a voluntary program that provides financial and technical assistance to agricultural producers to plan and implement conservation practices that improve soil, water, plant, animal, air and related natural resources on agricultural land and non-industrial private forestland.

  http://www.nrcs.usda.gov/wps/portal/nrcs/main/national/programs/financial/eqip/

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2. Stewardship for Climate Change Adaptation and Mitigation

Joshua Morse
Yale School of Forestry & Environmental Studies

"What are we learning about the science of stewarding conserved land to maximize climate benefits, including both adaptation and mitigation?"

"I have read many definitions of what is a conservationist and written not a few myself, but I suspect that the best one is written not with a pen, but with an axe… A conservationist is one who is humbly aware that with each stroke he is writing his signature on the face of the land"
–Aldo Leopold

What are we learning about stewarding conservation land to maximize climate benefits, such as greenhouse gas reduction and resilience in the face of changing weather patterns? This question is particularly relevant as land trusts transition from primarily focusing on acquiring properties for their conservation values to stewarding those same values in perpetuity. Looking ahead, it seems likely that the relevance of land conservation as a field will be increasingly viewed in terms of the benefits that land trusts bring to the environment and society through their management of the lands they are entrusted with. In this light, climate change presents an opportunity for increasingly stewardship-focused land trusts to address two major problems at once.

By positioning themselves as forward-looking stewards of conservation land with an eye towards securing climate benefits for the communities they serve from the properties they protect, land trusts can elegantly transition away from an acquisition model as the demand for this work declines. At the same time, by helping communities respond to climate change, land trusts will be making key contributions to the most pressing environmental challenge of the 21st century. In this chapter, we address these opportunities in two sections, dealing respectively with management strategies geared towards climate change adaptation and mitigation.

The initial section of this chapter addresses climate change adaptation—the work of bolstering social and ecological systems against anticipated climate change conditions—through a discussion of the science of climate change as it pertains to human concerns such as health and economics. This treatment expands on the habitat management strategies introduced in the preceding chapter by taking a forward-looking approach to questions of stewardship and focusing on opportunities to maximize the social benefit of conservation land in an uncertain future.

The second section addresses climate change mitigation as a stewardship opportunity. Mitigation—the work of minimizing climate change impacts through reduction of atmospheric greenhouse gas concentrations—is most often discussed in terms of market regulations and changes in consumption and lifestyle. However, land use change and management practices contribute to the U.S. carbon budget as well, and the land conservation community is well positioned to help reduce land-related emissions through innovative stewardship techniques.

Taken together, these topics aim to advance the conversation surrounding the role of land trusts in a changing world with an emphasis on strategy and stewardship. In the sections below, we will (A) introduce the science behind climate change processes relevant to conservation land; (B) discuss key stewardship implications stemming from current research; (C) examine case studies of conservation organizations leading the way in adaptation and mitigation stewardship; and (D) consider the implications of these topics for land stewardship and the conservation community going forward.

2.1 Adaptation

When the land conservation community considers climate change adaptation, much of its attention has historically focused on the anticipated impacts of climate change on natural systems as distinct from human ones, as discussed in the preceding chapter. There, we considered a range of potential management strategies for helping wild places and wildlife adapt to the warmer temperatures, shifting water regimes, and evolving landscapes.

However, a broader conversation about adaptation is taking place in the scientific community, one that addresses the impacts of climate change on humans through our participation in linked social-ecological systems. In this section, we consider the ways that the land conservation community can advance human adaptation to a warmer world faced with new extremes of both precipitation and drought, through proactive land management.

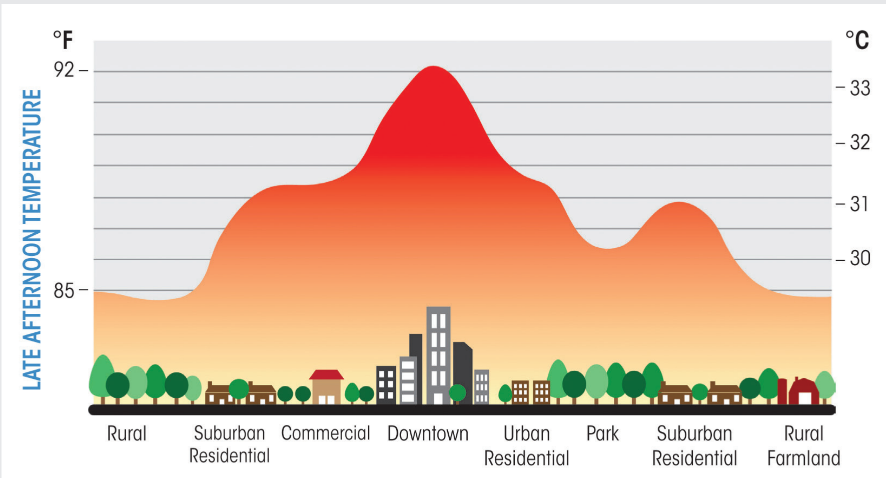
2.1.1 Temperature

We know that the planet is warming, but by how much, and with what consequences? The Intergovernmental Panel on Climate Change's 5th assessment (IPCC 2014) suggests a range of temperatures dependent on emissions scenario. With aggressive emission controls, the planet might warm between 0.3 and 1.7º C by the end of the century. However, under a high emission scenario, warming between 2.6 and 4.8º C is expected. And, in all emissions scenarios, more extreme high temperatures and less frigid lows are virtually certain (IPCC 2014).

Looking at global average temperatures can be problematic for getting a sense of what life – and land management – in a particular region will be like in a changing climate. In a well-publicized article in Nature, researchers interpreted global warming using the concept of climate departure. Climate departure refers to the point at which the average annual temperature for a given region will exceed the highest recorded averages for that same place from the beginning of record keeping until 2005. Mora et al. (2013) found that for mid-latitude cities like New York City and San Francisco, climate departure is expected to occur by the mid-21st century.

Research suggests that wildlife with strict thermal habitat requirements will either migrate to cooler regions as their native ranges warm, or perish (Malcolm et al. 2002), but what about humans? Unlike a population of migratory birds, major human settlements will not easily relocate as the planet warms. And, the impacts of a warming planet are expected to be particularly severe in urban areas. Pavement and concrete have a lower albedo – the capacity to reflect solar radiation – than the dense vegetation of a rural or forested landscape, translating into more solar heat stored by the land. These impervious surfaces also prevent the infiltration of water into the landscape, which helps greener landscapes mediate temperature (Kenward et al. 2014). As a result, urban areas are often considerably warmer than their rural surroundings (figure 1).

Figure 1: Urban Heat Island Temperature Distribution



http://www.cleanairpartnership.org/files/urbanheatisland.jpg

This effect – the urban "heat island" – averages roughly 1.3º C in the 60 warmest cities in the US during the day, with an even more pronounced nighttime effect (Kenward et al. 2014). In the most extreme cases, the urban heat islands can average as much as 4º C warmer than their rural surroundings. Because of these effects, urban areas see about one additional week per year of days over 90º F, and a slew of associated health impacts including heat stress and degraded air quality (Kenward et al. 2014).

2.1.1.1 Stewardship on a Warmer Planet

Against the backdrop of climate change, the urban heat island effect is a serious health risk. In cities, heightened global warming threatens respiratory health through increased exposure to ground level ozone and higher risk of heat stroke (Kenward et al. 2014). As in wild systems, land managers in urban areas have an opportunity to help respond to these changes through adaptive land management.

Urban land trusts often work in considerable areas of green space within the cities they operate in, placing them in a unique position to manage the land to help reduce the heat island effect. Because urban heat islands are largely driven by reduced albedo and decreased retention of soil water, management strategies that increase albedo and water retention can help to locally counter the heat island effect (Mackey et al. 2012). Two management strategies for this purpose have received considerable attention: the use of green infrastructure, such as shade trees and urban green spaces, and the installation of reflective roofs and pavement.

Street Trees, Ground Level Ozone, and Other Air Quality Concerns

Street trees can do more than simply keep the air cool; they can also help keep it clean. Ozone, formed when O_2 molecules are split in high-energy environments and re-assemble as O_3, is a double-edged sword. Atmospheric ozone helps shield the planet from incoming radiation, but at the ground level this same molecule can become concentrated and contribute to a wide range of respiratory health risks (EPAa).

As city planners and conservationists prepare for a warmer future where urban conditions are increasingly conducive to the formation and accumulation of ground level ozone (Akimoto 2003), street trees may play a front-and-center role (Kroeger et al. 2014). In addition to providing shade that both blocks incoming radiation and decreases temperatures, street trees can absorb ozone—and other air pollutants linked to climate change, like particulate matter and sulfur dioxide—directly. Modeling studies suggest that during peak ozone-producing conditions, citywide street tree plantings could help reduce ozone by 16% during concentrated time intervals (Nowak et al. 2010).

However, planners considering street trees to combat air pollutants should be careful not to create new health concerns. For example, under warming conditions, research suggests increased intensity and duration of pollen production from a wide range of plants, including the notorious ragweed and many urban street tree species (FAO). Although the linkage between climate change, increased pollen production, and urban street trees requires further research, recent reviews of the primary literature suggests that climate change-heightened pollen production should not be discounted as a public health concern (Roy et al. 2011).

Fighting for the benefits of urban green space is familiar ground for the land trust community, which has taken on a new significance in the context of global warming. At the scale of a single building, shade trees can offset direct insolation and reduce the need for air conditioning by 35% (Rosenfeld et al. 1995). At a larger scale, modeling studies suggest that citywide shade tree plantings can reduce average temperatures by between 0.3 and 1º C during midday (Akbari et al. 2001). Urban shade trees cool their surrounding environments through two mechanisms:

- Shading: shading reduces the amount of solar energy which makes direct contact with thermal reservoir surfaces like building walls and street pavement. Shade trees absorb or reflect between 70% and 90% of sunlight in their immediate footprint, which translates to surface temperature reductions of 20-45 ºF for walls and pavement immediately beneath them (EPAb).
- Evapotranspiration: evapotranspiration is the process by which trees absorb water from the soil, process it, and release it as water vapor through their leaves (EPAb). The phase change that occurs during this process draws heat from the surrounding environment, cooling the air around the trunk and leafs (Bowler et al. 2010). This “oasis effect” can range from 3.6-14.4 ºF for urban street trees (Taha 1997).

Urban vegetation, including both street trees and green space like parks and green roofs, can also reduce urban heat island effects by increasing the amount of solar energy reflected back into space. Very simply, highly light-absorbent surfaces like dark pavement capture more solar energy as heat than do reflective surfaces. Researchers have found that green space can have roughly four times the albedo of dark surfaces like pavement (Susca et al. 2011).

Combining the mechanisms of shading, evapotranspiration, and increasing albedo, replacing pavement with vegetation at a parcel scale—a building parking lot, for example—has a pronounced cooling effect, which can be heightened as plant life grows denser and more diverse (Mackey et al. 2012). While cities may be loath bear the costs of managing heavily vegetated green spaces year after year, land trusts are well positioned to advocate for and maintain such areas, which offer habitat and water control benefits in addition to providing some relief for intense heat islands.

Green Space & Baltimore

Owning and managing green space in an urban environment is a challenge for public and private landowners alike. The pressure to cash out and develop is considerable, and the effort involved in maintaining wild spaces in a jungle of concrete is significant.

Land trusts like Baltimore Greenspace are perfectly suited to helping cities and communities retain beneficial urban green space, by taking on the mission of owning and stewarding forest patches, community gardens, and small parks. Baltimore Greenspace is a small land trust that currently stewards a handful of parks and community gardens in Baltimore, Maryland, and has reached an agreement with the city for the purchase of municipally-owned lots with green-space value. Moreover, the organization recognizes that the habitat, health, and climate adaptation benefits of urban forest protection offer an avenue for expansion. By highlighting the benefits of urban forests and partnering with state and community groups interested in forest stewardship, Baltimore Greenspace is helping to raise awareness of the importance of green infrastructure and raise its profile.

For more information, visit:

http://baltimoregreenspace.org/forest-patches/how-we-help-2

While green space has many benefits, in terms of maximizing albedo for heat reduction the most effective management strategies are not strictly green. Reflective roofing and white pavement have been shown to significantly increase albedo in areas where they are implemented (Lei et al. 2014). Similarly sized areas of reflective roofing out-perform even the densest vegetation in terms of their ability to reflect solar radiation (Mackey et al. 2012), with albedos roughly 16 times as great as dark pavement, and eight times as great as green space (Susca et al. 2011). White roofing can also be installed in areas not suited for green space or urban tree planting, a useful feature given that roof space alone accounts for 20-25% of the urban surface (Susca et al. 2011). Models suggest that if implemented aggressively and globally, reflective pavement and roofs have tremendous cooling potential, roughly equivalent to the capture of 44 gigatons of CO_2, an offset worth around $1,100 billion at a value of $25/ton of carbon (Akbari et al. 2009).

Green Infrastructure Synergies

Although rarely discussed in the primary literature, the potential for synergy between green infrastructure like street trees, bioswales, and reflective pavement and roofing is considerable. To date, the best applications of both strategies can be seen in green alley projects which incorporate reflective pavement made of permeable substrates, in tandem with green infrastructure, to reduce stormwater management problems while also minimizing heat island effects. Section 2.1.2.1 details the mechanisms behind bioswale and green alley technology more thoroughly, and cites high-profile cases of their successful application.

2.1.2 Changing Weather: Wetter, Drier, and Higher

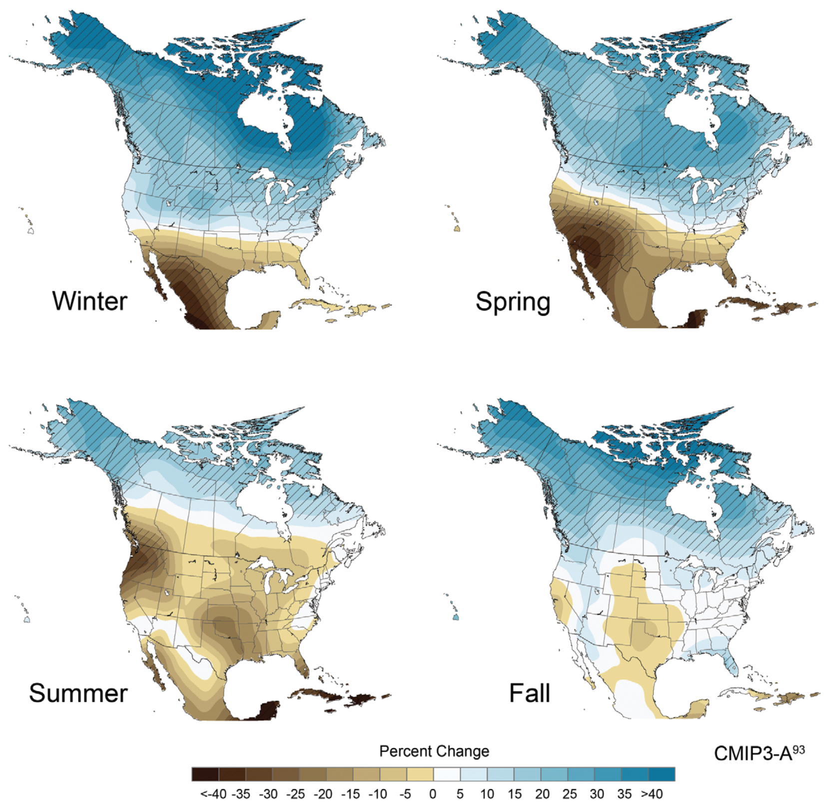
Water resources will pose a major challenge for managers across the U.S. as climate change intensifies. As temperature warms and weather patterns shift, regions like the American west and southwest are expected to face increasingly severe and frequent droughts and fires, while northern states and the Pacific Northwest will likely become wetter even as seasonal extremes in wet and dry spells intensify (Union of Concerned Scientists). With regards to fresh water availability, wet areas will get wetter, dry areas will get drier, and management challenges in both will be exacerbated (Figure 2; NCAS). At the same time, sea level rise will present its own suit of challenges in coastal communities (IPCC 2013).

In areas expected to see increased precipitation, primary management concerns center around adapting to the impacts of flooding, erosion and runoff management (Purdue Extension). Rainstorms historically categorized as 1 in 20 year events are expected to become more common, occurring roughly 4 in every 15 years. The intensity of rainfall during harsh storms is expected to increase as well, by between 10% and 25% over the course of the 21st century (Union of Concerned Scientists). The impacts of intense precipitation to riverbanks, agricultural lands, and municipalities will require innovative management responses.

In addition to storm water management, climate change will require coastal communities and land trusts to confront yet another water management challenge: sea level rise. Although the exact degree of sea level rise is expected to vary regionally, the IPCC's 5th assessment broadly suggests that average global sea level rise should be between 0.26 and 0.97 meters by the end of the century, depending on emissions scenario (IPCC 2013). In some areas, these numbers translate into much higher figures. Areas along the Hudson River valley and New York coastline are bracing for a figure closer to two meters (Scenic Hudson).

In contrast to the challenges of rising seas and intensifying precipitation, some land trusts will be faced with the work of managing for increasingly dry conditions. The western United States have experienced a period of sustained drought which, though not yet comparable to historic 'megadroughts' of the past millennia, are thought to be a harbinger of things to come under an increasingly warm and arid climate (Cooke et al. 2004). Warming temperatures and correspondingly earlier snowmelt also correlate with increased risk of and intensity of wildfire (Westerling et al. 2006). Accordingly, land managers in the western U.S. will need to consider management that minimizes fire risk and maximizes water availability, quality, and retention in a more arid, fire-prone environment.

Figure 2: Projected Future Changes in Precipitation in North America



The maps show projected future changes in precipitation relative to the recent past as simulated by 15 climate models. The simulations are for late this century, under a higher emissions scenario.[91] For example, in the spring, climate models agree that northern areas are likely to get wetter, and southern areas drier. There is less confidence in exactly where the transition between wetter and drier areas will occur. Confidence in the projected changes is highest in the hatched areas.

Global Climate Change Impacts in the United States, Thomas R. Karl, Jerry M. Melillo, and Thomas C. Peterson, (eds.). Cambridge University Press, 2009.

2.1.2.1 Stewardship Under Changing Weather Regimes

Land management that accounts for changing precipitation and water availability is a rapidly growing discipline. In the northern U.S., both urban and rural land trusts are bracing for more intense and more frequent storm events with novel management strategies.

In the rural landscape of the northeast, natural systems offer promising opportunities for managing increased storm water. Research suggests that land management geared towards reconnecting rivers with their native floodplains can have marked flood control benefits, in addition to improving habitat for aquatic species (Sommer et al. 2011). Likewise, riparian forests along naturally meandering stream channels – especially those in system headwaters – provide both water quality and flood and erosion control services (Kozlowski 2002).

The mechanisms by which both processes benefit watershed health and downstream water quality are similar to those described later in this section for bioswales and other green infrastructure, but at a grand scale. In situations of intensified precipitation, riparian forests slow the flow of surface and groundwater entering river systems (Chesapeake Bay Program). This mediation can help keep peak flow from reaching damaging intensity, and can also help stabilize flows over time. Both erosion risk and fluctuation in flow are anticipated climate change impacts for many rivers (Palmer et al. 2009), and both have consequences for stream ecology and for down-stream users, such as farmers or city water districts. As such, municipalities like New York City are investing in conservation and forest management in their up-stream watersheds to ensure reliable, clean drinking water as climate change intensifies.

Water Quality as a Land Conservation Benefit

Rural land conservation to benefit regional water quality has a long history. New York's Catskill Mountains are perhaps the most iconic example of this tradition, which has now entered a new stage thanks to a partnership between New York City and the Catskill Center, a local land trust. With funding from the city, the Catskill Center is protecting riparian forestland essential not only to ensuring the city's supply of quality water, but also to maintaining the health of local watersheds in the face of climate change. The partnership takes advantage of the Catskill Center's local reputation and investment in a healthy landscape and the City's interest in regional water quality, to benefit both rural and urban communities.

For more information, visit:

http://catskillcenter.org/streamside/

Urban areas in the northern U.S. will also have to contend with increased storm water issues, but unlike rural regions, urban areas largely rely on engineered systems for storm water management. As in the previous section, the land conservation community is helping to meet this challenge of climate change with green infrastructure solutions. A prime example of this effort is the installation of bioswales, engineered depressions in the urban landscape filled with highly permeable soil and flood resistant plants, to help capture and control runoff from impervious paved areas (Soil Science Society of America).

Figure 2: Diagram of a Bioswale

Bioswale diagram courtesy of New York City Department of Environmental Protection.

Bioswales perform a range of water management functions, which include collecting and moving stormwater, improving water quality through filtration, and improving water infiltration into (and retention in) the underlying soil. These benefits are all achieved using the same basic mechanisms, described in detail on the SUNY ESF web page and summarized below:

- Bioswales collect stormwater through strategic placement at low points on the landscape, often replacing traditional gutters or storm drains. This provides a useful means of reducing sewer loading or surface water accumulation over impermeable pavements.
- Once trapped, stormwater velocity is significantly reduced by the bioswale's plant community and depth, allowing for long term storage or conveyance with minimal risks of erosion.
- Trapped or conveyed water is filtered and suspended sediments are removed as it flows through the bioswale's plant community and porous soils.
- Porous soils enable trapped stormwater to infiltrate back into the groundwater, rather than being conveyed out of the city's catchment by a more traditional grey infrastructure system.

Bioswales are not the only form of green infrastructure. Street trees, in addition to their thermal and air quality benefits, can also help reduce the impacts of runoff from intense rain by intercepting and slowing the accumulation of surface water (American Forests). And, "green alleys" outfitted with permeable soil and a wide range of vegetation can help slow and store runoff at a large scale, while also mediating heat island effects (Newell et al. 2013). Conversely, green alleys can also help with water retention in arid regions, as described in the box below. Additionally, green infrastructure techniques can be applied outside of the urban landscape to benefit population centers. The Connecticut Institute for Resilience and Climate Adaptation (CIRCA) notes that engineered wetlands along the Connecticut coast could reduce the impacts of storms and floods within urban areas (CIRCA).

Los Angeles' Green Alleys

The city of Los Angeles is teaming up with the Trust for Public Land to address its paucity of parks, help manage a strong urban heat island effect, and improve its storm water treatment and storage infrastructure all in one fell swoop. Green alleys, with light-colored, permeable pavement, extensive plantings, and improved public access make the project a compelling and versatile solution to a suite of problems. Los Angeles' program is part of a larger movement to address urban green space, water management, and heat island effects with green alleys that also includes cities like Chicago and Montreal.

For more information, visit:

https://www.tpl.org/media-room/green-right-our-alley

To address the risks of rising sea levels, a medley of management and planning strategies are relevant to coastal land trusts. In the short term, managing for healthy wetlands to defend against the effects of higher-than-average storm surge applies strategies similar to floodplain conservation and management along inland river systems (Coastal Resilience). However the long-term implications of sea level rise mean that land trusts must also contend with the reality of permanent inundation of some parcels, and the inward migration of the tidal zone and marshlands (Feagin et al. 2010). Both rural and urban land trusts are responding to this science with marsh restoration and land acquisition projects designed to provide resilient coastal zones now and in the future. Support for such projects is increasingly coming from cities concerned with stormwater management and coastal encroachment, a pathway described in detail in the subsequent chapter on urban resilience below.

The benefits of green infrastructure solutions to stormwater management, rising sea levels, and rising temperatures (as described in section 2.1.1.1) can extend beyond the strictly environmental. Relative to traditional grey infrastructure solutions, green infrastructure can be cost-effective. Financing green infrastructure projects is further discussed in Chapter 4 on financing urban resilience.

Managing for a Rising Tide

The Hawaiian Islands Land Trust faces a remarkable predicament as it plans for the management of its Waihe'e Refuge. The property, which is home to endangered species and historic sites, could see inundation of considerable swaths of its 227 acres as sea level rises. To manage for this possibility, the land trust is applying restoration ecology to return the refuge to the most resilient state possible. It is hoped that intact sand dunes and diverse communities of native vegetation will facilitate a smooth adaptation to changing conditions.

For more information, visit:

http://climatechange.lta.org/case-study/hilt_waihee_restoration/

Both urban and rural landscapes in the American west are preparing for a different suit of climate change challenges: wildfires and drought. Wildfires are a natural element of forest processes in much of the west and southwest, where low-intensity, relatively frequent fires historically helped mediate forest dynamics (Stephens 2005). However, fire intensity and frequency is expected to increase with climate change. Beginning in the early 20th century, federal fire suppression policies began to lay the foundations for more intense fires made possible by more densely stocked forests with greater buildup of understory vegetation and downed woody debris (Stephens 2005). Today, these conditions interact with increasingly warm, dry climate to heighten the risk of intense, large scale fires even further (Brown et al. 2004). Such fires impact a wide range of conservation values including:

- Habitat: intense forest fires can level large forested areas in a way not common under natural fire regimes, and recovery from such fires can take decades. This is especially concerning in the boreal forests, where warming temperatures may make it impossible for traditional cold-tolerant tree species and communities to re-establish after intense fires (Kelly et al. 2013).
- Forest carbon storage: fires release above ground forest carbon both during the immediate combustion of biomass, and through the subsequent decay of dead biomass. Additionally, burnt-over landscapes take time to regain primary producer communities to begin storing carbon again through photosynthesis, and even longer to re-establish as forests with long-term above ground carbon storage potential (Buckley et al. 2014).
- Water quality: wildfires compromise water quality by destroying the plant communities which stabilize soil across watersheds, increasing the vulnerability of downstream rivers and reservoirs to high concentrations of sediment-rich runoff, and in some cases producing ash that can contaminate water bodies directly (Buckley et al. 2014).

Managing conservation land for increased fire frequency and intensity centers around forestry practices which reduce fuel-loads and alter forest structure to minimize vulnerability to intense fires. Fuel-treatment – the reduction of woody debris, dense understory vegetation, and heavily stocked forest stands – mimics the impacts of frequent, low intensity fires. With reduced fuel availability, modeling studies show that the footprint of wildfires can be reduced by 30-76%, and the acreage of high-intensity burning that is most damaging to forests and watersheds can be decreased by 75%. Additionally, by reducing available fuel through both mechanical thinning and removal, as well as controlled burns, managers can improve forest health and generate biomass and other timber products (American Forest Foundation).

The Finance of Fire Management

Forestry designed to increase the resilience of watershed lands to wildfires is rapidly gaining the interest not only of conservation organizations, but of municipalities and private sector funders. Through the fuel-treatment management techniques described above, modeling studies suggest that investors can make tremendous savings in avoided costs that would be incurred in a high intensity wildfire, such as property damage and watershed restoration (Buckley 2014). Two very different organizations – Morgan Stanley and the City of Santa Fe, NM – showcase the wide appeal of this sort of proactive management to a range of investors. UC Berkley business students won Morgan Stanley's 2015 Sustainable Investing Challenge with an innovative proposal to monetize the benefits of watershed timber management among stakeholders including water districts, energy utilities, and municipalities in order to finance proactive fire control (Morgan Stanley). The City of Santa Fe is working along similar lines, implementing a payment for ecosystem services program to expand funding available for the management of its watershed lands beyond the limited federal dollars it has previously relied on (City of Santa Fe 2013). Funding mechanisms for fire adaptation management are discussed in greater detail in the chapter on rural conservation finance below.

Land managers in the west are also looking to strategies for increasing the availability and conservation of water in an arid landscape. The Clark Fork Coalition, a watershed advocacy group, in partnership with the Bitterroot Land Trust, applies habitat restoration work to maximize water available for irrigation and stream-flow in the headwaters of the Bitterroot watershed (LTA). Strategies such as improved irrigation techniques and dam removal have benefitted both organizations by improving stream health and meeting the agricultural needs of the local irrigation district (Clark Fork Coalition). Strategies for water conservation are available to rangeland managers as well. Research and anecdote suggest that rotational grazing and careful livestock management – such as the holistic management approaches pioneered by the Savory Institute – can help recover rangeland plant communities, which benefit water retention and quality on rangeland systems (Sherren et al. 2012).

2.1.3 Implications

The adaptation strategies discussed in the sections above should not be viewed as single-problem fixes. Rather, many of these techniques have the potential to address multiple challenges, and should be engaged with an eye towards capturing these co-benefits.

As cities plan not only for warming temperatures, but also increasing storm water management challenges, the ability of green spaces to address these concerns in addition to their albedo benefits are compelling. And, partnerships like the Trust for Public Land and the City of Los Angeles, recognizing that these strategies should not be mutually exclusive, are finding ways to integrate reflective pavement and green infrastructure into innovative green alley landscapes that function optimally to reduce heat islands and manage storm water.

In rural landscapes, protecting watersheds from the effects of increased runoff goes hand in hand with wildlife habitat conservation. From the headwaters of the Catskills to coastal deltas in the west, connecting streams with their floodplains and protecting riparian forest offers benefits ranging from erosion control to shade for coldwater fisheries to expanded habitat for a range of wildlife. Likewise, sound watershed management in the American west also buffers the landscape again the risk of wildfire, in both cases relying on proactive silviculture.

As the land conservation community addresses climate change adaptation with human systems in mind, a clear theme with regards to best management practices is beginning to emerge. The most economic, innovative, and effective strategies for adaptation – whether in response to warming temperatures or increasing precipitation impacts on rural landscapes – are those that work in natural systems to marry many interests and provide a multitude of services.

2.2 Mitigation

Adaptation strategies offer land trusts a wide range of options for dealing with a warmer world subject to more extreme weather, but do not address the pressing question of whether the land trust community can help reduce the threat of climate change proactively. In this section, we examine the science behind climate change mitigation through the reduction of greenhouse gas emissions and concentrations, and consider stewardship options for land trusts interested in taking part in the global movement to minimize the intensity of climate change, rather than just simply bracing for its impacts.

The terrestrial carbon stock, including carbon trapped in organic and mineral soils, shrubs and herbaceous plants, and trees, accounts for a tremendous amount of the earth's carbon budget. Soil carbon in particular is a crucial store, almost triple the size of the atmospheric carbon stock (Ontl & Schulte 2012). Recognizing the importance of terrestrial carbon as an opportunity to combat climate change, government agencies and NGOs in the U.S. and abroad are taking steps to study and encourage carbon management in terrestrial systems (McGlynn et al. 2016). With its stewardship interest in much of the privately protected land in the U.S., the land conservation community is well positioned to lead the charge in the realm of land management for carbon sequestration as a means of climate change mitigation.

However, a wide range of obstacles running the gamut from technical, to legal, to political and ecological stand in the way of the conservation community's full engagement with mitigation stewardship. While the carbon cycle dynamics of forest and grassland communities—both working and wild—have received considerable scholarly attention, uncertainty remains with regards to best management practices for carbon sequestration in many cases (Ballessan & Luyssaert 2014; DeLonge et al. 2012). In cases where best practices have been identified with confidence, encouraging adoption of what may be perceived as restrictive measures by private landowners and other stakeholders can be difficult. Additionally, the continuously evolving nature of climate change raises questions about the long-term relevance of mitigation techniques that make sense today.

In response to these challenges, leaders in the land conservation community have applied a wide range of strategies to gain a beachhead in the arena of mitigation stewardship. Forest managers are increasing their emphasis on curbing the rate of deforestation and managing for forest diversity to pave the way for adoption of more novel approaches to carbon sequestration silviculture as scientific consensus and political climate allow (USDA). Agricultural land trusts and think-tanks are building on the linkages between carbon sequestration techniques and improved range condition to engage their ranching constituents (Savory Institute 2013). Taken together, these cases suggest that mitigation stewardship has the potential to be an important area for stakeholder engagement and innovation in land conservation, and a crucial piece in the fight against climate change.

2.2.1 Carbon Cycling & Sequestration

Climate change mitigation encompasses the full range of strategies for limiting the accumulation of atmospheric CO2 and other greenhouse gases, whether by decreasing emissions or recapturing greenhouse gases already in the atmosphere. In both forest and grassland systems, a range of stewardship techniques can be applied to prevent the loss of presently sequestered carbon, and to recapture and sequester atmospheric greenhouse gases. In order to grasp these opportunities, a basic understanding of the carbon cycle is useful.

In both forest and grassland systems, photosynthesis drives the carbon cycle. Plants capture atmospheric carbon and convert it into carbohydrates which are stored in biomass—the leaves, stems, and roots of plants. In a simplified system, aboveground (plant-based) carbon is eventually converted to below-ground (soil) carbon as plants die and are incorporated into the soil as soil organic carbon. Ultimately, soil organic carbon can be slowly transformed into inorganic forms in the mineral soil (USDA). Systems continue to acquire carbon through these mechanisms until the rate of accumulation slows to match the rate of carbon loss through leaching and decomposition, at which point the soil carbon pool is said to have reached equilibrium (Jandl et al. 2007).

Although the basic mechanisms of carbon capture and storage in forest and grassland systems are similar, some key differences between them exist. Due to the short lifespans of grassland plans, the vast majority of grassland carbon is stored in the soil (Diaz et al. 2009). While forests store considerable amounts of carbon in the soil as well, they can also sequester significant carbon in their comparatively long-lived dominant plant species.

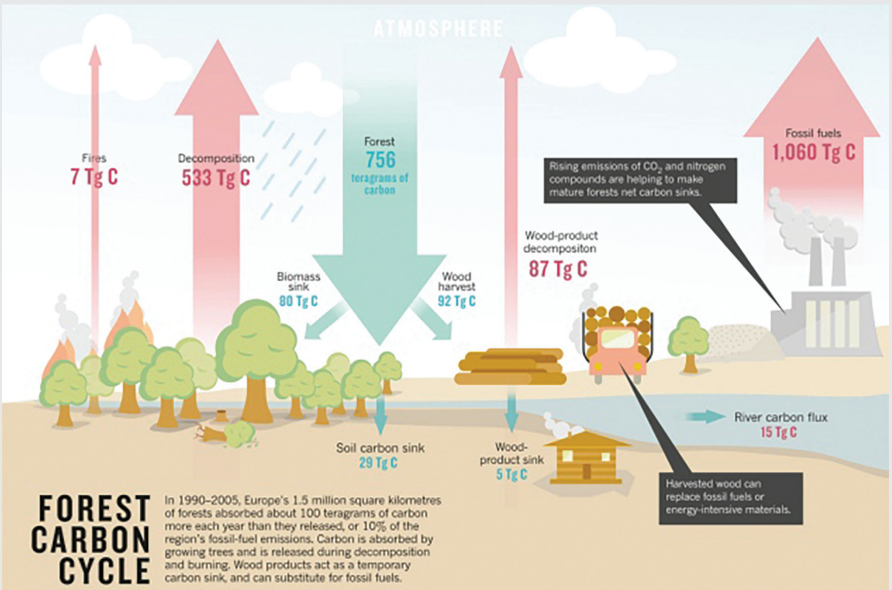
Most scientists believe that because of this two-fold sequestration potential, forest systems have greater total carbon storage capability than grasslands (Science Daily), although some disagreement on this point exists (Wei et al. 2012). Additionally, because forests have both above and below-ground carbon sequestration potential, and because it is relatively easy to measure forest above-ground carbon storage, much more is known about forest carbon sequestration than grassland carbon sequestration (Diaz et al. 2009).

Carbon that is generally stored in above ground plant structures or in organic soils does not always remain sequestered. In forests and grasslands, a range of pathways allow stored carbon to escape and return to the atmosphere as a greenhouse gas.

2.2.1.1 Forest Carbon

Even without human influence, carbon trapped in plants and soils in forests can return to the atmosphere. Decomposition naturally accounts for the release of carbon from dead organic matter, and processes like wildfires can release vast amounts of carbon stored in both live trees and organic (and in some cases mineral) soils through combustion (USDA). Adding human activities to the equation, forest carbon is lost in tremendous quantities through deforestation, as timber harvested for fuel is burnt, wood products decomposes, and erosion and disturbance to the soil releases soil carbon (figure 3).

Figure 3: Forest Carbon Cycle



Bellesan & Luyssaert et al. 2014.

2.2.1.2 Grassland Carbon

In grassland systems, decomposition and fires also release sequestered carbon naturally. However, a range of other processes – both human and natural – can also account for greenhouse gas emission. In fertilized systems, addition of synthetic nitrogen supplements can increase plant production of N2O, soil compaction by livestock and agricultural machinery can lead to erosion which can physically remove soil carbon from the system and disturb microbial and fungal processes associated with soil carbon storage, and respiration by livestock can indirectly convert sequestered carbon into emissions (DeLonge et al. 2014).

2.2.2 Mitigation Stewardship

Best practices for mitigation in forest and grassland systems have been the subject of considerable research, and continue to receive much attention. Although certain practices specific to each system bear key similarities, this section divides its review by system type for clarity.

2.2.2.1 Forest Management For Mitigation

Three broad strategies exist for managing forestland with climate change mitigation in mind:

Avoided Conversion: The central tenet of mitigation management in forest systems has been a rallying cry for the conservation movement for decades: keep forest as forests. When forests are leveled, much of the carbon stored in above ground biomass like the leaves and stems of plants is released into the atmosphere, while a relatively small amount is slowly transferred to the soil (Houghton et al. 1983). Depending on the fate of the wood products from a given act of deforestation, the speed of carbon release from above-ground biomass can vary; wood incorporated into long-lasting structures contributes carbon to the atmosphere slowly, while wood burned to make way for agriculture or other non-forest uses transmits huge amounts of carbon to the atmosphere quickly (Moutinho & Schwartzman 2005). Above-ground biomass accounts for about one third of the planet's forest carbon stock (Dixon et al. 1994). Below-ground carbon, equal to roughly two thirds of the planet's forest carbon stock, can also be influenced by deforestation. Deforestation increases the rate of organic matter decomposition in surface soils (IPCC 2000), and burning can also impact organic soil carbon – and in some cases even carbon stored in the mineral soil (USDA). Thus, preventing deforestation outright is one of the most effective forest management strategies for limiting carbon emissions.

- **Afforestation & Reforestation:** Afforestation is the practice of establishing tree cover on a site which has been bereft of it for a significant period of time, while reforestation is returning a recently deforested site to a forested state. Both practices have similar mitigation benefits in the eyes of the IPCC (2014). Afforestation and reforestation advance mitigation goals by increasing the ability of the landscape to capture atmospheric carbon through photosynthesis. This increases a landscape's aboveground carbon store in the form of new tree biomass, and also replenishes its below ground soil organic carbon. The effects of afforestation are most pronounced when fast-growing species are introduced to landscapes that have been free of forest cover for some time (Jandl et al. 2008).

- **Improved Forest Management:** A range of management practices designed to enhance the capture of atmospheric carbon are available to land mangers once forestland is protected from conversion or reestablished through afforestation or reforestation. Because photosynthesis drives the capture and sequestration of atmospheric carbon, and because plants both store carbon in their living tissue and facilitate its transfer to the soil, forest managers can tailor practices to maximize these pathways for sequestering atmospheric carbon. Depending on location, tree community and structure, and landowner goals, such strategies may include:
- Extending rotation between cuttings, to increase the length of time that carbon stored in living trees is allowed to stand on the landscape (Perschel et al. 2007).
- Increasing stocking and productivity through timber improvement cutting that favors highly productive individuals and species (Perschel et al. 2007).
- Minimizing erosion and damage to non-harvest trees and other primary producers during silvicultural activities (USDA).

Downeast Lakes Land Trust and Forest Carbon Management

The Downeast Lakes Land Trust in Grand Lake Stream, Maine, presently holds 19,000 acres in the California Air Resource Board's greenhouse gas cap and trade program. Enrolled in the program to generate income for the protection of additional land and to produce management income, the Downeast Lakes Land Trust woods were an excellent fit for mitigation management. Much of the forestland in northern Maine's Washington County has been heavily and repeatedly harvested, resulting in dense, young stands. Such woodlots are prime candidates for management that maximizes stocking and productivity, which in the case of the Downeast Lakes Land Trust property results in a fairly hands-off approach at this stage in the forest's life with high potential for capture and sequestration of above-ground carbon.

While laissez-fare mitigation stewardship was a natural fit for the young, rapidly growing woods managed by Downeast Lakes Land Trust, its mangers acknowledge the possibility of challenges down the road. Downeast Lakes Land Trust is deeply embedded in the community of Grand Lakes Stream, a politically diverse town where forest management for extra revenue and in support of further traditional conservation goals is well received…but where the idea of stewardship for climate change mitigation might be less readily accepted. Enrolling additional acreage in cap-and-trade programs is a compelling opportunity for the land trust, but one that will require careful community relations. Additionally, the minimal harvesting conducive to carbon sequestration in today's young forests could come into conflict with incentives to cut for market as the woods mature, or with funding for wildlife management that requires habitat conditions not easily reconciled with mitigation stewardship. Such concerns must be carefully weighed before enrolling additional acres in cap-and-trade.

For more information, visit:

https://www.downeastlakes.org/

2.2.2.2 Grassland Management For Mitigation

In grassland systems, carbon sequestration in biomass is a relatively brief process due to the short-lived nature of the dominant plant species. Much more significant is the incorporation of carbon into the soil organic matter. As such, management strategies designed to maximize grassland carbon sequestration focus on improving the carbon storage potential of grassland soils. Because these strategies are often relevant in both 'true' grassland settings, such as the California range, and in a wide range of other agricultural systems, this section discusses both grassland management and agricultural practices suited to improving carbon sequestration.

In the U.S., the land conservation community's stake in the management of true grassland systems may be best embodied in pastures and rangelands. In these settings, carbon cycling and sequestration is significantly impacted by both plant community processes and by the activities of domesticated ruminants such as cattle. In such settings, the following strategies are valuable to mitigation efforts:

- Rotational grazing and other holistic management practices to limit and direct the impact of ruminants on pasture land to minimize erosion and compaction and maximize soil fertilization (Savory 2013).
- Seeding with native plant mixes to maximize photosynthesis for a given habitat type and region (DeLonge et al. 2014).
- Soil amendment with organic fertilizers—rather than synthetic nitrogen or phosphorus rich substances—to increase plant uptake of carbon and microbial activity (DeLonge et al. 2014).

In non-range agricultural systems, several additional techniques are also useful:

- Use of cover crops during the off-season to maximize photosynthetic carbon capture on the land (USDA).
- Reduced tillage/no-till practices to minimize disruption of soil and microbial communities associated with soil organic carbon storage (NOFA 2015).
- Soil supplementation with biochar—a technique similar to organic fertilizer amendment—that has not yet been tested in rangeland systems, but is practiced in some agricultural settings (Lehmen et al. 2006).

Marin Agricultural Trust and Grassland Carbon Sequestration

The Marin Agricultural Land Trust (MALT) serves farmers and ranchers in Marin County, across the bay from San Francisco. Aware of the carbon emissions associated with traditional farm and rangeland management practices, MALT has developed a management guidance process that incorporates elements of NRCS conservation planning to evaluate carbon sequestration potential on protected rangeland and provide prescriptions for its improvement.

To date, these Carbon Farm Plans have been implemented on three pilot ranches. In addition to holistic management prescriptions for the full range of systems on the ranch designed to enhance water and soil quality and habitat, specific carbon sequestration goals for rangeland have been identified. As an initial step, these pilot ranches have applied organic compost to amend their rangeland soils for improved soil carbon sequestration. With baseline data in place, these pilot projects will be monitored post-amendment, and additional practices for improvement of carbon sequestration after will be identified and applied based on emerging data.

While these pilot efforts are promising, MALT and other land trusts interested in grassland carbon sequestration do, like Downeast Lakes Land Trust, anticipate obstacles to wider application of their efforts. Although grassland carbon management is gaining credibility in the climate mitigation dialogue (USDA), government and private funding for application of grassland mitigation stewardship techniques lags behind similar support for forest mitigation stewardship (McGlynn et al. 2016). And, changing future conditions may complicate efforts that make good sense in the present. While rangeland soil amendment with organic fertilizer is a practical measure for improving carbon sequestration in pastures, some conservationist question whether rangeland carbon will stay in the ground if climate change forces major changes in the land use of the present-day range (Kelly, personal communication, 2016). Finally, as in Grand Lake Stream, Maine, the social nuances of introducing climate mitigation-driven management to a politically diverse demographic like ranchers can be challenging. Gaining widespread support for mitigation stewardship in the larger context of the American range remains a challenge for the future.

For more information, visit:

http://www.malt.org/

2.2.3 Implications

Like any form of stewardship, management for climate change mitigation is sensitive to ecological context, and as such will be variously applicable in different settings. However, a wide range of best practices for both forest and grassland systems are already available and new research is continuously delving further into the possibilities of management for climate change mitigation. Thus, the greater obstacles to the land conservation community in engaging with climate mitigation are not ecological, but economic and political.

The potential conflicts of interest between management for wildlife goals, future timber harvests, and forest carbon sequestration discussed in the Downeast Lakes Land Trust case, and the implications of social context for rangeland carbon sequestration in Marin County, highlight the reality that climate change mitigation remains one of many management priorities even in best case scenarios. Whether it is the place of the conservation community to prioritize climate mitigation, habitat, and economic goals broadly, the potential for conflict between them emphasizes that more thought needs to be given to establishing mitigation as a stand-alone conservation interest on par with traditional values.

A Role for Community Conservation?

The Mendocino Land Trust is finding opportunities to support its traditional land conservation and recreation mission while also making the case for mitigation behaviors that go beyond land management. MLT received a nearly $500,000 grant to partner with state agencies and other NGOs to install electric car charging stations at remote hiking trailheads along the northern California Coast. The initiative sends a strong signal that MLT supports emission reduction through personal choices—like driving fuel efficient vehicles—in addition to the more traditional management strategies that fall in the land conservation wheelhouse.

Projects like this, which straddle the divide between mitigation management and outright political advocacy, may be a powerful way for land trusts—and other conservation organizations—to become more active in shaping a community-wide response to climate change. For example, the Shannondale, MO, branch of the United Church of Christ was able to save its historic outdoor church and tree farm by enrolling in the California Carbon Air Resource Board's cap-and-trade-program (Finite Carbon 2013).

Judy Anderson, principle at Community Consultants, sees this alignment of interests as crucial. "My observation is that community relevance, equity, and transitioning to a 'service leadership' model is increasingly seen as the core to the long term viability of conservation", she writes. "That's true for climate action, too".

For more information, visit:

http://www.mendocinolandtrust.org/?What_We_Do:Current_Projects%26nbsp%3B:EV_Charging_Stations

2.3 Conclusions

Establishing new priorities in a field as venerable as land conservation takes time. As evidenced throughout this section, planning tools that suggest novel strategies for land management in the face of climate change are abundant, but the barriers to their implementation are high (Stein et al. 2013). While it is natural for conservationists—whose decisions will impact landscapes and both natural and human communities for generations—to be conservative in acting on cutting edge science when much about climate change remains uncertain, there are great costs associated with inaction. Chronesky et al. 2015 illustrate this point best in their observation that present day management choices have the potential to either limit or expand the range of future management options for a given natural system, but that inaction almost always results in limited options down the road. A crucial first step in incorporating climate change adaptation and mitigation into the conservation community's core priorities may thus be overcoming our collective fear of managing under uncertain conditions, and learning to embrace adaptive management practices that will preserve a wide range of options for both mitigation and adaptation in the future. Recognizing the importance of this paradigm shift, the National Wildlife Federation outlines a nine-stage process for "climate smart conservation", which centers on practical measures for making management decisions today that keep as many doors open for the ecosystems of tomorrow as possible (Stein et al. 2014).

Possible Questions for Discussion

- Adaptation and mitigation stewardship should be seen as complementary, but in cases when land trusts have limited resources to apply to addressing climate change, how should they allocate them? Does practicality justify a focus on adaptation? Does the commitment to perpetuity demand a focus on mitigation?
- Does the land conservation community have a role to play in advocating for emissions reduction behavior that goes beyond stewardship? Should land trusts allocate resources to promoting renewable energy, energy efficient technologies, and personal commitments to emission reduction such as plant-based diets?
- How can the urban land trust community expand its influence/mission to include the most effective adaptation strategies, like implementation of reflective roofing and pavement, when these approaches are not strictly 'green'?
- Can we find funding opportunities for urban heat island reduction, which presently seems to receive less attention than urban water management and sea-level buffering as an adaptation and resilience topic?
- Mitigation science, especially for forestland, often assumes that forest productivity will continue under climate change scenarios basically un-changed. But, we know trees will become more stressed as the climate changes. Will the forests of tomorrow be as effective carbon sequestration vehicles as contemporary forests? How should managers plan for changing forest health in relation to forest carbon?

Some of the Organizations Doing Interesting Work on this Topic

- American Forests — a forestry think-tank with a wide range of information on traditional and urban forestry approaches for carbon sequestration, as well as more general forestry topics.

  https://www.americanforests.org/who-we-are-about-us/

- City of Chicago Green Alley Program — a useful resource on integrating green infrastructure, particularly green alleys, into an urban landscape. An excellent case book in PDF form, detailing program goals and a range of pilot projects, is available via link from the program's home page.

  http://www.cityofchicago.org/city/en/depts/cdot/provdrs/street/svcs/green_alleys.html

- Clark Fork Coalition — a watershed advocacy organization working in several Montana watersheds to manage for ecological and economic vitality. Their projects offer useful examples of the kinds of management activities that can be undertaken to improve stream health in a mixed-use landscape.

  http://clarkfork.org/

- Coastal Resilience (The Nature Conservancy) — an information hub organized by The Nature Conservancy to aggregate science and other resources for adaptation to sea level rise, and to support and promote proof-of-concept projects in a wide range of coastal systems.

  http://coastalresilience.org/

- EcoAdapt — an information hub which helps governments, NGOs, and other groups look at their policies and practices with an eye towards climate adaptation. Website includes links to consultant web pages, knowledge exchange programs, and resources for adaptive behaviors and management.

  http://ecoadapt.org/about

- Marin Carbon Project — a collaboration of researchers and practitioners in Marin County, CA, working to better understand and promote rangeland carbon sequestration through carbon farming techniques. Loosely affiliated with the Marin Agricultural Land Trust.

  http://www.marincarbonproject.org/

- Northeast Organic Farmers Association (Massachusetts) —the Massachusetts branch of a regional consortium of organic farmers, with a wide range of information on best practices and resources within the trade. NOFA provides useful recommendations for vegetable growers and non-rangeland farmers interested in managing for carbon sequestration.

  http://www.nofamass.org/

- Savory Institute — a global think tank that researches and promotes holistic grazing and land management techniques with the primary goal of improving the quality of rangeland systems, especially in the face of drought and desertification.

  http://savory.global/institute

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3. Climate Finance and Conserved Landscapes

Colin Kelly
Yale School of Forestry & Environmental Studies

How are markets for carbon stored in conserved lands evolving, both voluntarily and through regulations?

- Regulatory markets that produce demand for carbon offsets are expanding in size and geographic scope, but policy uncertainty persists, causing many practitioners to consider other revenue streams.
- Voluntary markets are seeing somewhat lower prices, but are projected to grow over the next ten years. The market is growing for offsets that provide other social and ecological benefits beyond carbon.

What are the most important sources of funding emerging around the services provided by conserved lands in the face of climate change?

- Carbon storage remains the largest service for which investors are willing to pay, but important new markets are continuing to be developed for other services such as drought, flood, and wildfire mitigation.
- New synergies are emerging among climate adaptation, resilience, and mitigation on conserved lands.

How we use lands has a tremendous bearing on climate change, with agriculture, land use, and forestry responsible for just under a quarter of global anthropogenic emissions (IPCC 2014).

At the same time, how we use and manage lands can also play an important role in helping societies mitigate the many threats posed by climate change; awareness of this potential is increasingly prevalent in both domestic and international policy (USDOS 2016). The scale of the mitigation opportunity is significant — U.S. forests, prairies, farmland, and other natural habitats remove 850 million tonnes of CO2 equivalent from the atmosphere per year, equivalent to 16% of the United States' annual carbon dioxide emissions (Forest Trends, Feb 2016). In addition to this annual sequestration value, these ecosystems also store a tremendous amount of carbon—with U.S. forest ecosystems alone holding 70 billion tonnes of CO2e (USDA 2008).

Estimated U.S. Carbon Stocks, 2013

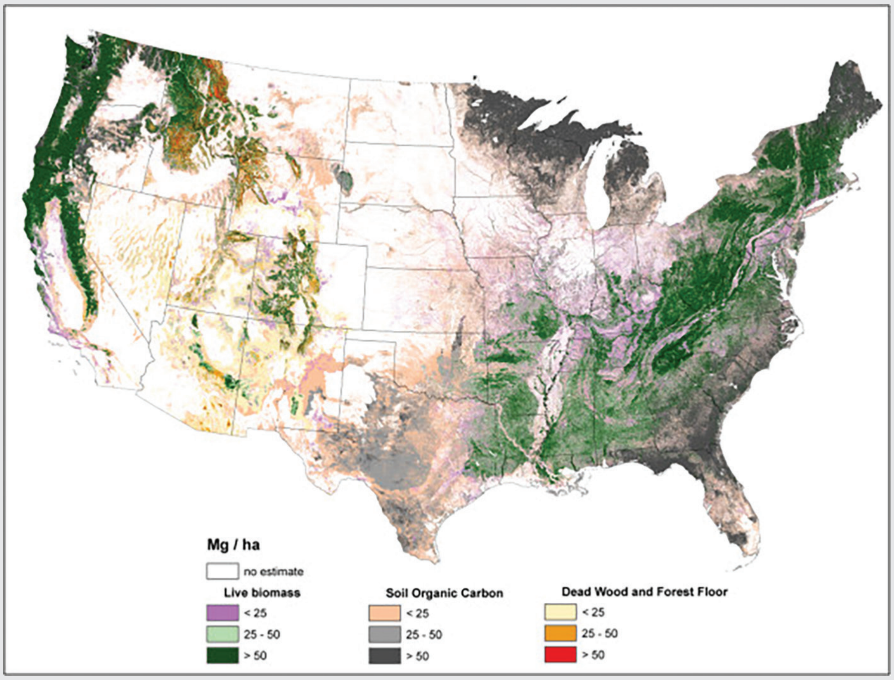


Figure 9 Major forest carbon pools with the plurality of total forest carbon stock for each pixel imputed from forest inventory plots, conterminous U.S., 2000-2009. Major pools are: 1) living biomass (aboveground, belowground, and understory), 2) dead wood and forest floor (including standing dead, down dead, and forest floor), and 3) soil organic carbon.

from

Wilson, Barry Tyler; Woodall, Christopher W.; Griffith, Douglas M. 2013. Imputing forest carbon stock estimates from inventory plots to a nationally continuous coverage. Carbon Balance and Management. 8:1.

http://cbmjournal.springeropen.com/articles/10.1186/1750-0680-8-1

Conservation activities have an essential role to play in preserving these landscapes and their ability to absorb and store carbon. Conservation prevents conversion of landscapes to uses that do not naturally store and sequester carbon. An old growth forest, for example will hold far more carbon in its soils and vegetation if it is not converted to a parking lot. Planting trees on degraded lands and improving how we manage forests can also add to the amount of carbon being stored on a piece of land, and/or improve the ability of a landscape to absorb and retain carbon. These mechanisms are explored in detail in the earlier chapter on Adaptation, Mitigation and Stewardship.

As governments, businesses and other entities organize themselves to confront climate change, significant revenue streams have become available for conservation and stewardship projects that can demonstrate that they are preventing carbon emissions and/or increasing rates of carbon sequestration and storage. These revenue streams can come from a number of sources. Over the past decade, carbon-offset projects have made up the bulk of climate related revenue for conservation projects, as emitters seek to compensate for the impact of their carbon pollution, either voluntarily or because they are mandated by regulation. Incentives for carbon sequestration and storage on conserved lands can also come from public sources, such as revenue from the auction of permits to emit carbon or from existing federal or state programs that are being retooled to help mitigate climate change.

In addition to storing carbon, conserved lands can provide valuable services in the face of a changing climate, improving resilience to climate related risks such as sea level rise, drought, flooding, and wildfire. These are also explored in more detail in the Adaptation, Mitigation and Stewardship Chapter above.

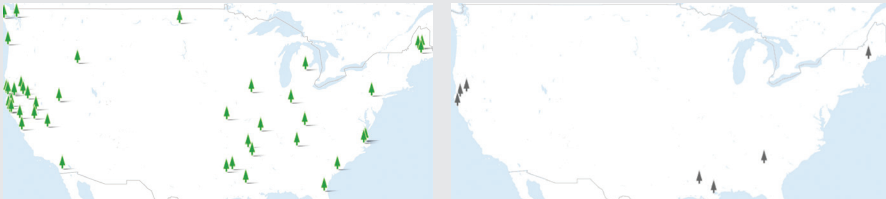
Demand for more resilient, climate change-adapted landscapes is also generating revenue streams to support conservation activities. Adaptation and resilience related revenue can come from mechanisms such as water sharing agreements between cities and conserved agricultural land, payments for forestry treatments in watersheds that supply urban areas and which are vulnerable to catastrophic wildfire, or increased demand for conservation/habitat credits to bolster resilience of certain species in the face of a changing climate. Buyers of these services range from companies and developers to municipal water suppliers to state and federal government agencies.

This chapter will survey some of these revenue opportunities for conserved rural lands in the face of a changing climate, and will explore some of the challenges that land trusts and conservation practitioners are facing as they seek to tap into these revenue streams.

3.1 Carbon Offset Markets

Numerous individuals and organizations are working to increase the cultural diversity across users of natural areas. The following represent some leaders of these efforts.

US Forest Carbon Offset Projects, May 2016



The map on the left shows operational forest carbon projects in North America and the one on the right shows projects that are in the pipeline.

http://www.forestcarbonportal.com/project/

Purchasing a carbon offset, which is sold as a tonne of carbon dioxide equivalent (CO_2e), is a way for governments, firms and individuals to compensate for their emissions by providing financial support for projects that reduce or absorb CO_2e emissions elsewhere. Offsets can be a low cost way for governments, companies, and individuals to contribute to climate change mitigation either on a voluntary basis, or as a way of complying with a mandatory climate change policy.

There are two parallel (and sometimes overlapping) offset markets in the US:

The older, voluntary market driven by offset demand from environmentally conscious individuals and corporations, as well as those seeking to prepare their businesses for expected climate policies in the future, and

The compliance market driven by firms seeking to meet requirements under California's cap-and-trade program, a program which has linked with Quebec and is planning expansion to include Ontario and Manitoba.

California's cap-and-trade program was approved as part of Assembly Bill 32 that requires California to return to 1990 levels of greenhouse gas emissions by 2020, and was updated to reduce emissions to 40% below 1990 levels by 2030. It went into effect in 2013. The program sets a CO_2 limit that covers 85% of sources of the state's emissions, and requires that polluters either reduce their emissions directly, buy an emission reduction credit from a an entity that has reduced their emissions, or purchase a carbon offset. Offsets are allowed for up to 8% of a facility's compliance obligation (CARB, 2015). The California Air Resources Board administers the program.

Is a Carbon Offset Just a License to Pollute?

While carbon-offset markets have proven to be a significant revenue opportunity for conserved lands, they are by no means uncontroversial in the larger climate and environmental movement. Critics point to the fact that purchasing an offset allows polluters to continue polluting (both carbon and criteria air pollutants, often in lower-income communities), as long as they pay for a carbon offset. Many are also concerned that offset projects themselves have been ethically dubious and caused social harm to nearby communities.

In response to such political opposition and early mistakes, many carbon offset markets now adopt strict protocols for what types of projects can receive offset revenue, but for many, the whole notion of offsets is fundamentally flawed.

For more information, visit:

http://www.carbontradewatch.org/

In order to certify that it is actually reducing emissions, any offset project needs to register with an accredited greenhouse gas program. These programs, which are in essence independent nongovernmental organizations, include the Verified Carbon Standard, Climate Action Reserve, American Carbon Registry, and many others. With a general goal of providing quality assurance in carbon markets, these programs use a peer review process to approve different protocols for generating offsets and certify that individual projects are actually generating promised reductions. The American Carbon Registry, for example, has approved 22 different methodologies for generating an offset, 10 of which are related to agriculture, forestry and land use (American Carbon Registry, n.d.). Some, but not all, of the protocols that the registries approve are in turn adopted by the California Air Resources Board for use in its mandatory program (CARB, 2016).

3.1.1 Supply of Forest and Land Use Carbon Offsets

There are many different ways that credits can be created, but the ones most relevant to conserved land are those based on projects that either protect natural areas from development or enhance the ability of forests, grazing lands and agricultural lands to store carbon. The biophysical mechanisms of carbon capture and storage on conserved land are explored above in the chapter on Adaptation, Mitigation, and Stewardship.

While carbon offset protocols related to agriculture, soil carbon, grazing schedule, compost addition, and others could all end up providing valuable revenue streams for land trusts going forward, forestry has been the most common type of offset project on U.S. conserved lands. Forestry offsets can be generated in three basic ways in order to be considered in voluntary or compliance programs (Jenkins 2015, Jenkins & Smith 2013).

- **Improved Forest Management** generates offsets in two separate ways. First, by compensating land holders for carbon stocks that are above the regional average, and second, by implementing silvicultural prescriptions that add to both onsite and wood product carbon stocks.

- **Avoided Conversion** generates offset credits by preventing the conversion of existing forests or grasslands threatened by development. This can provide revenue to land trusts seeking to acquire and protect new lands that have high existing stores of carbon.
- **Afforestation** generates offset credits by increasing carbon stocks on degraded or deforested areas. This can provide revenue for land trusts seeking to purchase and/or restore land that does not have much carbon on site, but has a high storage potential.

Project lists and short descriptions of carbon offset projects carried out using these three different strategies can be found on project developer websites (Blue Source, n.d.; Finite Carbon, n.d., TerraCarbon, n.d.).

Examples of Offset Projects Using Each Methodology

Improved Forest Management - Downeast Lakes Land Trust

"In partnership with a leading Maine land trust, Finite Carbon developed the nation's first California Air Resources Board Improved Forest Management project. The 19,100 acre spruce/fir and northern hardwood project in southeastern Maine generated nearly 200,000 offsets at initial registration and is expected to generate 400,000 total offsets during the project's first 10 years."

http://www.finitecarbon.com/project-experience/

Avoided Conversion - North Carolina Forest Projects

"In select regions of North Carolina, rising commodity prices and agricultural land values have exerted considerable pressure for land owners to convert their forest holdings to row-crop agriculture. In order to prevent such conversion and to find viable alternative revenue streams, the owners of five forested properties in the region joined with Blue Source to protect nearly 5,000 acres of native pine and bottomland hardwood forests. Conservation easement values, coupled with projected revenues from carbon offset sales, motivated these landowners to embark on Avoided Conversion projects, thereby maintaining these lands as forests in perpetuity."

http://bluesource.com/casestudy

Afforestation - Tensas River Basin Project

"With project design and validation support services from TerraCarbon, The Nature Conservancy developed an afforestation project on 406 acres of privately owned former agricultural land in Franklin Parish, Louisiana. The native bottomland and hardwood tree species planted on the site are expected to capture and store 112,390 tonnes of CO_2 over the course of the 70 year project life. This restored agricultural land is linked to nearly 10,000 acres of public lands by the Tensas River, and together provide critical habitat for many species, including black bear."

http://terracarbon.com/projects/summary/

In different ways, each of these project types generates an offset by putting in place measures that result in the storage of additional carbon over a business-as-usual baseline. They must also be measurable, verifiable, additional (above what is achieved as a result of regulation or other measures in place before the outset of the project), and permanent, which in practice means that the measures put in place cannot be undone for 60-100 years, depending on the protocol that is used.

Avoided Conversion credits remain popular for land trusts that are working to protect new lands from impending development, especially in areas threatened by urban encroachment. However, the fact that projects must represent carbon storage that is "additional" over what was already being stored means that lands that are already protected in fee or in easements are ineligible for Avoided Conversion credits. Lands that are already protected are, however, often eligible for Afforestation, and Improved Forest Management credits.

Finite Carbon's Process For Generating Revenues With a Land Trust Partner ...

1) Conduct a feasibility study of the forest.

2) Complete a carbon inventory of the forest.

3) Select appropriate registry/protocol (e.g. ARB, CAR, ACR, or VCS).

4) Translate inventory into carbon model.

5) Prepare and submit project plan.

6) Hire a third part verifier once plan is accepted and registered.

7) Submit project verification to registry and receive allocation of carbon offsets.

8) Market and sell carbon offsets in proprietary network or engage top brokers to broaden sales process.

... and their rough assessment of average potential revenue streams by U.S. region.

Region	Project Revenue ($/Acre)	
	1st Year	*Annual*
California/PNW	$800-1200	$20-40
Coastal Alaska	$300-1000	$10-20
Inland West	$200-1000	$10-20
Southeast Hardwood	$200-800	$10-30
Southeast Softwood	$150-200	$10-20
Lake States	$100-400	$5-20
Northeast	$100-250	$5-10

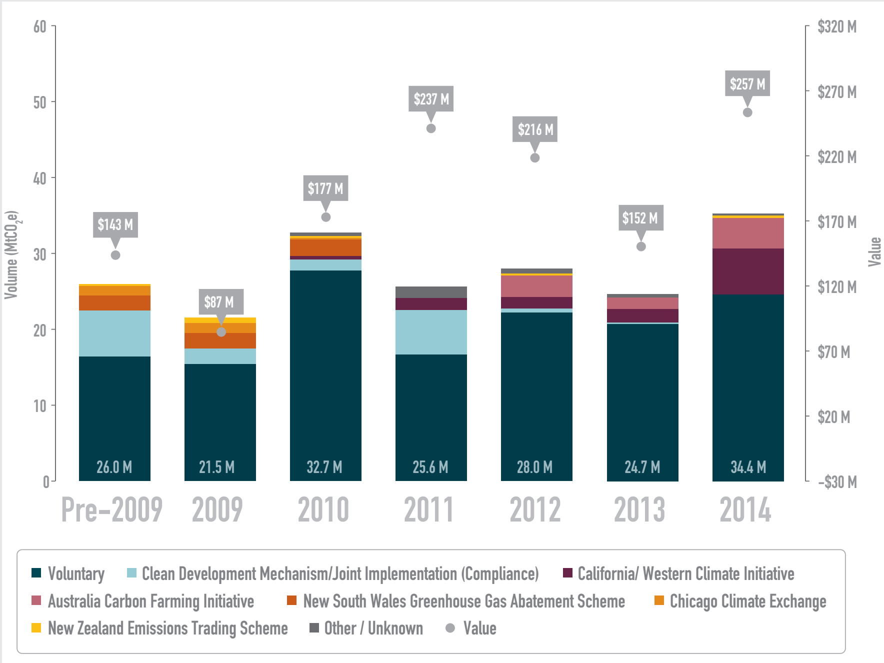
For more information, visit:

http://www.finitecarbon.com/wp-content/uploads/2015/06/FiniteCarbon-FLA-article-June-2015.pdf

http://www.finitecarbon.com/solutions/land-trusts/

Usually contracts for offset projects are structured so that the project developer carries out most of inventory, modeling, and coordination activities and, in turn, receives a percentage of the revenues from carbon sales. How quickly the revenues become available can depend on the type of project. Avoided conversion, for example, comes as one lump sum in the beginning, while Improved Forest Management results in a slow drip, as money comes in from offset sales (and out from Monitoring and Verification expenses) year on year after the reductions have been verified by a third party. Offset developers and sellers can sell multiple years' worth of credits up front, though this of course means that they incur some level of risk should the project fail. If a land trust wants to use the money for stewardship, it can use funds received up front to start an endowment, or it can incorporate projected revenues from annual carbon sales in its annual operating budget.

Historical Market-Based Payments for Forest-Based Emissions Reduction: Transaction Volumes and Values



http://www.forest-trends.org/documents/files/doc_5020.pdf

3.1.2 Demand for Forestry and Land Use Offsets

Both voluntary initiatives and government regulations have historically driven demand for offset projects on conserved land. The graph above shows overall payments for forest based emission reductions internationally. Globally, in 2014, $257 million was paid for 34.4 million worth of forestry offsets (Forest Trends, Nov. 2015). Over half of these offsets come from the UN's Reducing Emissions from Deforestation and Forest Degradation (REDD+) program, which offers incentives to developing countries to reduce emissions from their forest lands.

3.1.2.1 Voluntary Offset Market Outlook

Demand from corporate buyers remains high, a dynamic that could continue given the successes achieved at COP 21 in Paris. With 23.7 million forest-based voluntary offsets contracted in 2014, voluntary demand remains strong. However, supply of offsets is projected to continue to outstrip demand in many scenarios, which is leading to lower prices (Forest Trends, June 2015). But voluntary offsets are not commoditized—there are many different project types with perceived higher quality projects able to command higher prices. Successful players are finding that they need to adapt to a market that is increasingly rewarding social and ecological co-benefits (Environmental Finance 2015). This trend is explored in more detail in Section 3.1.3.4 of this document.

3.1.2.2 Compliance Offset Market Outlook

Global demand for compliance offsets increased 200% between 2013 and 2014, with businesses in California purchasing six million credits to offset their emissions. The increase in California came as transportation fuels were added to the list of sectors required to reduce their emissions under state climate law (Reuters 2015).

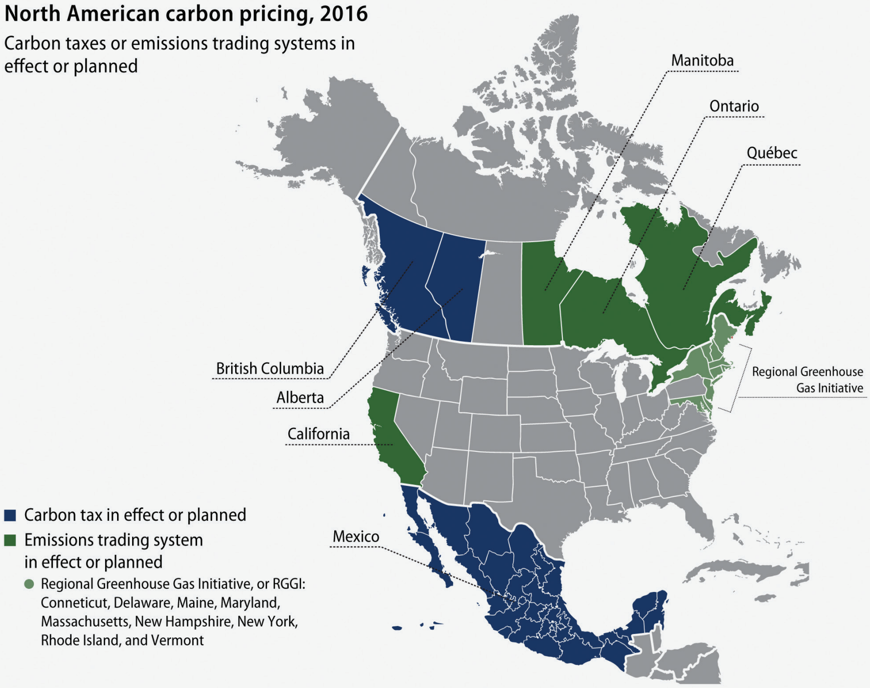
The map on the below shows the geographic scope of current and planned carbon pricing schemes in North America. The California-Quebec market, which will soon be linked with Manitoba and Ontario, generates the vast majority of demand for carbon offsets. Despite allowing for the use of offsets, (RGGI, n.d.) the Regional Greenhouse Gas Initiative (RGGI) which covers electric utilities in the Northeastern United States, is subject to a cap that is not overly stringent, resulting in low demand, and therefore low prices of offsets. RGGI officials do not anticipate offsets coming into the market until allowance prices rise significantly higher (Ecosystem Marketplace, n.d.).

Historical Market-Based Payments for Forest-Based Emissions Reduction: Transaction Volumes and Values

FIGURE 1

North American carbon pricing, 2016

Carbon taxes or emissions trading systems in effect or planned



Sources: Alexandre Kossoy and others, "State and Trends of Carbon Pricing 2015" (Washington: World Bank, 2015), available at http://www.worldbank.org/content/dam/Worldbank/document/Climate/State-and-Trend-Report-2015.pdf; Official Website of the Ontario Government, "Memorandum Of Understanding Between the Government of Ontario, the Government of Québec and the Government of Manitoba," December 7, 2015, available at https://news.ontario.ca/opo/en/2015/12/memorandum-of-understanding-between-the-government-of-ontario-the-government-of-quebec-and-the-gover.html; Alberta Government, "Climate Leadership Plan: A summary of Alberta's new policy response to climate change," available at http://www.alberta.ca/climate-leadership-plan.cfm (last accessed March 2016).

Center for American Progress: https://www.americanprogress.org/issues/green/news/2016/03/17/133564/an-opportunity-to-develop-a-north-american-price-on-carbon/

British Columbia uses revenue from its "revenue neutral" carbon tax to cut income and corporate taxes, but its "Carbon Neutral British Columbia" initiative requires all public sector organizations to buy offsets to compensate for their emissions. In 2014, the largest of these offset projects was the Great Bear North and Central-Mid Coast Improved Forest Management Project, which partnered with First Nation groups and generated 300,000 offsets, while conserving vital habitat for the iconic "spirit" bear (Pacific Carbon Trust, 2014).

While growth in the California system is encouraging, there is currently a fair amount of uncertainty related to the role of offsets over time within that system. Entities that are required to participate in California's cap-and-trade program can buy offsets to meet up to eight percent of their emissions, but this may be subject to change going forward. The California Air Resources Board is working to update its Climate Change Scoping Plan in order to reflect the 2030 GHG target established by Governor Jerry Brown's Executive Order.

The Order called on California to reduce its emissions to 40% below 1990 levels by 2030. The update will include critical information about how California will meet that target, including the role of offsets.

For reasons mentioned earlier, environmental justice groups tend to oppose offsets as a climate policy tool. For example, the official Environmental Justice Advisory Committee on the proposed AB 32 Scoping Plan released its recommendations in April of 2014. Their report called on the State to "minimize or eliminate carbon offsets, and international forestry offset programs such as the international Reducing Emissions from Deforestation and Forest Degradation (REDD+), since it can diminish direct industrial emissions reduction at fence-line communities and compromise GHG reductions in the state," (CARB, 2014).

There is also a debate over whether REDD+ offsets should be included in California's cap-and-trade system. Some worry that international offsets will flood the compliance market with cheaper (~$1/tonne) offsets that will crowd out domestic projects. Others point out that if REDD+ has to adhere to the same, more stringent protocols as other ARB Credits, the price difference between domestic and international forestry offsets would likely become negligible.

While the regulatory market in California could be poised to grow significantly, these issues are all adding to policy uncertainty and giving land managers and offset developers pause — particularly before they commit their lands to long-term management practices based on the current standards for generating offsets.

3.1.3 Offset Projects: Challenges and Opportunities for Land Trusts

3.1.3.1 Challenge: High Costs and Risks with Small Margins

A successfully executed carbon project can produce much needed revenues to cover the many different types of cost related to acquisition and stewardship of protected lands. However, it is important to note that a lot of land trusts explore carbon project opportunities, but then decide not to implement them.

A major factor driving this decision is often the high costs associated with project development and ongoing annual monitoring and verification, costs that are required to confirm that the project is storing the promised carbon. This can be a burden for understaffed and cash-strapped land trusts. A generally accepted rule of thumb is that about half of all revenue for forest carbon projects is usually taken up by up front and ongoing costs. Carbon projects on grasslands or other landscapes that have lower carbon sequestration potential per acre, face the same operating and monitoring costs and, therefore, even smaller margins.

Project development costs are also a problem if the project is smaller and unable to achieve economies of scale. This problem can be circumvented if land trusts combine forces to aggregate their forested acreage under the same offset project. TNC's Working Woodlands project, explored in further detail in the following pages, aggregates many small private holdings into larger offset projects. However, the coordination required to make this type of aggregation possible comes with its own costs in terms of land trust staff resources, especially if local land trusts do not have a history of collaborating.

3.1.3.2 Opportunity: Funding for Stewardship

Many land trusts have used carbon-offset revenue to finance new acquisitions, but a number of them also use the revenues to support a range of stewardship activities on lands that they hold.

Case Study: Tennessee River Gorge Trust

Tennessee River Gorge Trust (TRGT) is in the process of finalizing a carbon-offset project that involves improved forest management on 5,500 acres of conserved land near Chattanooga, Tennessee. Working with Finite Carbon as a project developer, the Trust hopes to bring roughly 250,000 to 270,000 tonnes of carbon to market and generate approximately $2 million in revenue.

Instead of using that revenue for new acquisitions, they are considering using all (or most) to support the trust's stewardship activities. The estimated 4% return on the $2 million endowment would be enough to support the salary and other costs associated with a full time staff person. This new staffer would focus on traditional land trust duties such as coordinating research on key forest health indicators, marking boundaries, patrolling, and engaging with the community. TRGT plans to finalize the project in the summer of 2016.

For more information, visit:

http://www.trgt.org/#homepage

This offers an ongoing funding source and frees up other funding for other critical activities. Stewardship activities can range from hiring new land trust staff to improving infrastructure and access to funding land and habitat restoration.

3.1.3.3 Challenge and Opportunity: Offset Projects on Conservation Easements

While carbon projects have been successfully deployed in the context of conservation easements, it is often much more complicated than if the land is held in fee. Indeed, many land trusts do not engage in carbon markets because they do not own land in fee and the conservation easements they do hold are not written to allow for the easement holder affirmatively to engage in carbon-offset projects. The Tennessee River Gorge Trust, for example, has opted not to include a well-suited 500-acre parcel in the offset project it is currently working on because the easement was written 15 years ago, well before the advent of carbon markets.

Easement language does represent an opportunity for land trusts going forward. When a land trust receives a donated conservation easement, they usually solicit a stewardship donation in order to create an endowment to cover stewardship costs. An alternative would be for the land trust to work with the landowner to write the easement so as to enable carbon-offset projects on the land. These future revenues could then help cover the stewardship costs. The agreements could also be written to allow land trusts to generate stewardship revenue through ecosystem service markets beyond carbon. For example, an easement that Lyme Timber granted in the case of the Grand River Project included language that reserved the right to generate revenue from ecosystem service markets.

If there are no community relations or other issues standing in the way, land trusts do have options to consider if they want to alter (particularly by making more strict) existing conservation easements to be able to collect revenue from carbon. In a paper entitled "Adapting Conservation Easements to Climate Change," the authors suggest four primary options for changing land use restrictions: easement amendment, management plan revision, approval of changes through discretionary consent, and updating laws and policies codified in the easement (Rissman et al. 2014) The whole question of amending "permanent" conservation easements is, however, a contentious issue within the land trust community (LTA, 2014).

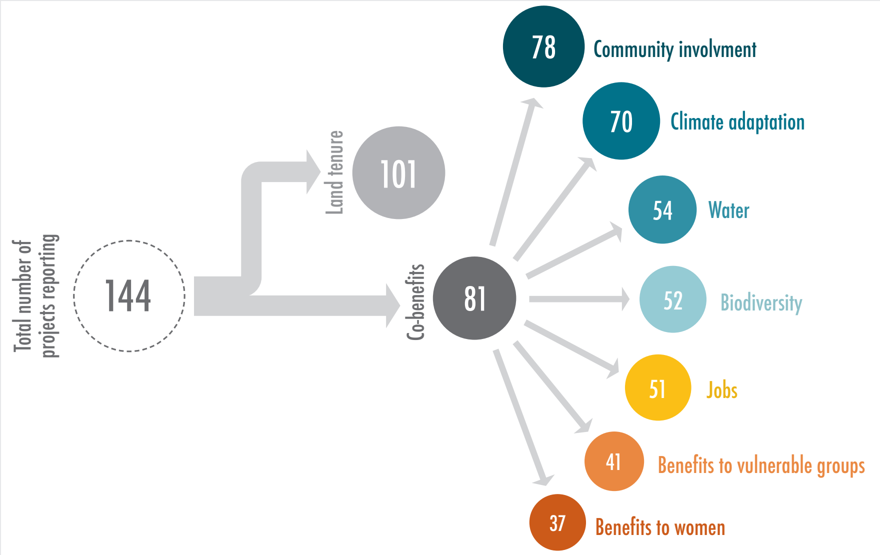
3.1.3.4 Opportunity: Delivering Multiple Values

A recent Report from Forest Trends entitled *Not So Niche: Co-benefits at the Intersection of Forest Carbon and Sustainable Development* suggests different indicators that may be tracked in order to ascertain the multiple values delivered by forest carbon projects. These benefits include land tenure and ownership, jobs, benefit sharing with local communities, impact on women and vulnerable and marginalized groups, biodiversity, water and climate resilience. A key takeaway of the report is that "project developers and buyers alike often say that the beyond-carbon impacts are the reason they are active in the carbon market" (Forest Trends 2016).

Most carbon-offset projects on conserved lands in the United States also seek to deliver multiple ecological and social benefits. Beyond just the fact that this is the right thing to do, there are several concrete benefits to designing projects that integrate multiple ecological and social values.

The first is that it can add monetary value to offset credits. Verified Carbon Standard has found that by verifying qualified offset projects under the "Climate, Community, and Biodiversity" standard, buyers will pay an average of $2.70 more per tonne (Environmental Finance, 2015). These higher prices could end up causing project developers to compete to deliver multiple values including protecting biodiversity, supporting local communities, reducing rural poverty and generating other important benefits.

Forest Trends' *Not So Niche* Report: Number of Projects Responding to Questions within Impact Categories



http://www.forest-trends.org/documents/files/doc_5153.pdf

Considering social, economic and ecological benefits in a carbon project can also provide land trusts with additional revenue streams, as they deliver additional benefits. If the project also improves habitat, it may be able to secure revenues from habitat banks or hunting clubs. However, it is important to note that there can be conflicts between managing land for carbon and managing land for habitat for important species. These conflicts are described in more detail in the chapter on Adaptation, Mitigation, and Stewardship above. There can also be questions related to additionality and double counting when seeking to "bundle" and be paid separately for the multiple services provided by the same piece of land, but there are usually ways of addressing these challenges (Cooley and Olander, 2011).

Case Study: TNC Working Woodlands

TNC's Working Woodlands program helps landowners in Pennsylvania to protect and manage their forested lands in ways that improve the biological health, diversity and economic value of the forest, while also confronting climate change.

The project uses some of the carbon revenue it secures through Avoided Conversion and Improved Forest Management projects to help landowners pursue Forest Stewardship Council (FSC) certification for their woodlands. This allows them to charge more money for the timber that they do harvest. The program also fosters partnerships with hunting clubs as a means of generating further revenue for landowners.

For more information, visit:

http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/pennsylvania/workingwoodlands/index.htm

Many practitioners and project developers are nervous about relying solely on carbon markets, and these additional revenue streams are a valuable hedge given uncertainties related to carbon-offset markets.

Just like a forest that is diverse in age class and species composition is more resilient to natural disturbances, so too is a management regime that considers many different types of values and revenue opportunities.

3.1.3.5 Opportunity: New Carbon Offset Protocols

As mentioned above, there are many new offset project protocols that have been submitted to various registries for peer review and approval. Some of these new ways of creating carbon offsets provide compelling opportunities for the land trust community to generate new revenues from conservation related activities. The American Carbon Registry has recognized the following project methodologies:

- Avoided Conversion of Shrublands and Grasslands to Agriculture
- Restoration of Degraded Wetlands in the Mississippi Delta
- Grazing Land and Livestock Management
- Compost Addition to Grazed Grasslands
- Reduced Use of Nitrogen Fertilizer

The Marin Carbon Project

A consortium of ranchers, scientists and nonprofits, including the Marin Agricultural Land Trust (MALT) successfully demonstrated that the one-time addition of compost to well-managed rangeland improves soil health and water retention, which nurtures better growth of carbon sequestering pasture grasses. The American Carbon Registry approved the protocol in 2014, allowing farmers who spread compost on their pastures to sell carbon offset credits in voluntary markets. Three MALT- protected ranches—Stemple Creek Ranch, Straus Dairy, and Corda Ranch—participated in trials to demonstrate the protocol's efficacy.

For more information, visit:

http://www.malt.org/protected-lands/carbon-farming

3.2 Beyond Carbon Markets: Other Existing and Emerging Sources of Climate Related Funding for Natural Areas

While carbon markets remain the most widely available source of climate related revenues for land trusts working in rural areas, there could be other compelling opportunities related to adaptation and resilience moving forward.

3.2.1 Carbon Market Allowance Revenues

As an alternative to developing carbon offset projects, land trusts can seek to tap into revenue streams that governments collect through the auction of emission allowances in cap-and-trade systems or the imposition of carbon charges. In California, it is required that these proceeds be spent on initiatives that achieve emissions reductions of some kind, while also yielding "substantial economic, environmental, and public health benefits for Californians, including meaningful benefits to the most disadvantaged communities," (CARB, Nov 2014).

The revenues are substantial—between March 2014 and December 2015, over $2.6 billion has been appropriated to State agencies to implement GHG emission reduction programs, projects, and activities—but so too are the demands from a number of political priorities beyond land conservation, with only $42 million going to the CA Department of Forestry and Fire Protection and $27 million to the Department of Fish and Wildlife (CCI 2016). Some of these funds have made it to help land trusts in conserving lands, with several million going to the Pacific Forest Trusts' Goose Lake restoration and conservation program in the form of a grant from the Department of Fish and Wildlife (Pacific Forest Trust, n.d.). Some in the land trust community believe that the level of allowance proceeds funding that goes to forest projects would increase substantially should the offset project approach be abandoned in the upcoming AB 32 Scoping Plan. Should the U.S. adopt a federal carbon tax, the revenues from that tax may at some point be mobilized for land conservation projects that help conserved lands and the communities around them mitigate and adapt to climate change. However, it is just as likely that the U.S. would chose to emulate British Columbia's "revenue neutral" approach, using carbon tax revenues to pay for corresponding reductions in income and corporate taxes.

3.2.2 Public Funding

Public funding, whether at the municipal, state, or national level, has always been a cornerstone of conservation finance, and federal programs such as the Land and Water Conservation Fund and the Forest Legacy Program have been conserving lands long before there was a consciousness about the value of carbon storage. However, federal initiatives are increasingly acknowledging the value of forests for climate change mitigation and adaptation, and there are a number of conservation projects designed around climate objectives (USDA, 2016).

3.2.3 Private Funding

Philanthropists and donor supported NGOs are also allocating resources to acquisition and conservation of land based on climate mitigation and adaptation objectives. Some examples from a White House summary of "private and public commitments to support resilient natural systems" (White House 2014) include:

- Through its Resilient Landscapes Initiative, the Open Space Institute (OSI) will invest $10.7 million and leverage as much as $53.5 million over the next 2.5 years to conserve land through purchase and easements in as many as 14 eastern states, from Maine to Alabama. Applying science developed by the Nature Conservancy, OSI will identify for its investments lands that are likely to facilitate wildlife adaptation to climate change, and reduce the potential risk of flooding and drought.
- The American Forest Foundation will contribute $10 million over 5 years to engage, train and support landowners in promoting climate friendly stewardship of forests, many in the highest priority carbon landscapes in the country.
- The Wildlife Conservation Society's Climate Adaptation Fund, with support from the Doris Duke Charitable Foundation, is announcing the award of $2.5 million to support 13 on-the-ground adaptation actions specifically designed to increase the resilience and adaptive capacity of terrestrial, freshwater and coastal ecosystems across the United States. Non-profit grantees will leverage an additional $2.5 million in private and public support for science-based projects that anticipate and respond to potential climate change impacts, while yielding sustainable, long-term conservation outcomes.

3.2.4 Municipal Water Utilities

System Conservation Pilot Program

In the Colorado River Basin, the Bureau of Reclamation, together with a collection of water utilities, has pooled $11 million to lease water rights that will flow to and be stored in Lake Powell for municipal use and electricity generation.

Given projections of a drier west, it is hoped that this water can give water and electric utilities more options as they manage the region's scarce water. Under the first phase of this program, the funding is going to lease water from agricultural water users, many of them conservation groups that hold water rights, such as TNC and Trout Unlimited.

The program calls for the water to be left in the river (where it delivers valuable in stream flow benefits) until it reaches Lake Powell. This water is freed up through practices such as crop switching, deficit irrigation, and rotational fallowing.

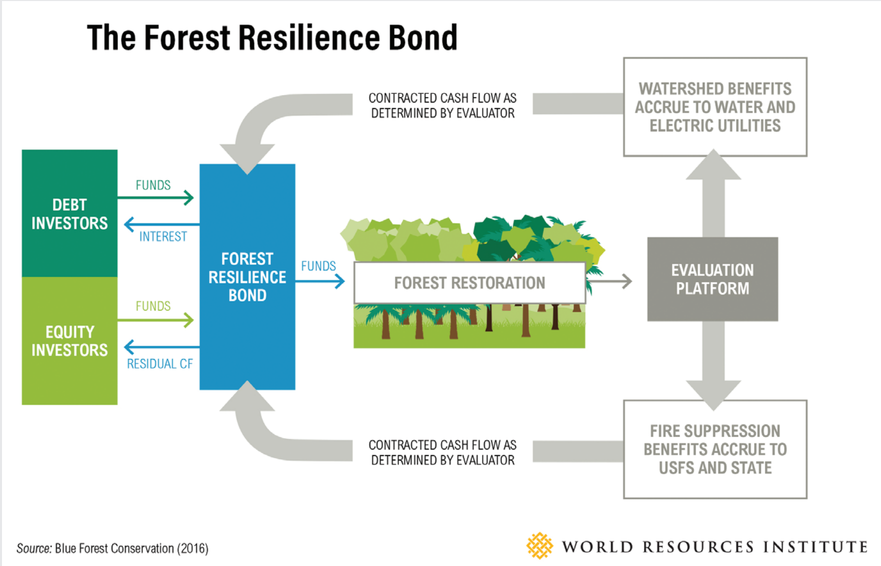
For more information, visit:

http://www.usbr.gov/newsroom/newsrelease/detail.cfm?RecordID=48006

As municipal water supplies become threatened by climate related impacts such as droughts, floods, or catastrophic wildfire, more water fees paid by users are becoming available for adaptation activities on conserved lands. Some examples include the following:

- **Leasing/Sharing Agricultural Water —** As the western United States experiences projected water shortages, there are emerging opportunities for land trusts that own water rights to participate in water leasing markets or enter into water sharing agreements with cities. These cities are often eager to add extra capacity to their water supplies, and to pay land trusts and other water owners for a portion of their water. If enough water can be kept on the land to sustain agriculture, conservation groups are finding that they can conserve farmland, generate new revenues, and help bolster urban resilience to drought (Colorado Open Lands, 2011).
- **Drought and Fire through Proactive Forest Restoration —** The right kind of forest management can help reduce the threat of catastrophic wildfires while also increasing water quantity. Blue Forest Conservation has developed a financial vehicle—which it calls a Forest Resilience Bond—that allows private investors to put money into forestry treatments that increase water quantity and reduce the risk of fire in the watersheds used by municipal water suppliers. The pay-for-performance model shifts upfront costs and risks to private investors, who are compensated by water utilities for the water quantity increases and the US Forest Service for the fire suppression benefits (Blue Forest Conservation, n.d.).

Blue Forest Conservation Project Structure



http://www.blueforestconservation.com/aboutlive/

3.2.5 Habitat/Conservation Banking

One potential revenue stream for land trusts in the future could be related to markets that emerge to incentivize creation or improvement of habitat for wildlife in the face of a changing climate.

For example, in Oregon, the EPA estimates that warm temperatures impair 35,000 miles of streams and rivers, which is highly detrimental to trout and spawning salmon. The Freshwater Trust and the Willamette Partnership have worked with the Oregon Department of Environmental Quality to develop a credit market for reducing water temperature, paying landowners to plant trees and reduce agricultural diversions (OPB, 2012). As temperatures increase, and the demand for cooler water increases, this type of market could grow.

Possible Questions for Discussion

- How should land trusts weigh whether the risks and costs of developing forest carbon offsets are worth the benefits to their stewardship activities?
- How can we get more easements in place that allow land trusts to sell forest carbon and use the fees to support stewardship (instead of or in addition to soliciting stewardship donations)?
- What are the best ways for land trusts to create and market high quality offsets?
- What are the pros and cons of small land trusts coming together to aggregate their forest carbon to make offset projects easier to administer?
- What are the opportunities and challenges for impact investors?
- What is an equitable split of carbon revenues and project risks between landowners, land trusts and project developers?
- How does climate change impact land trusts' goals related to access and inclusion?

Some of the Organizations Doing Interesting Work on this Topic

- California Air Resources Board – http://www.arb.ca.gov/homepage.htm
- Forest Trends – http://www.forest-trends.org/
- TNC Working Woodlands – http://www.nature.org/ourinitiatives/regions/northamerica/unitedstates/pennsylvania/workingwoodlands/
- The Pacific Forest Trust – https://www.pacificforest.org/
- Resources Legacy Fund – http://www.resourceslegacyfund.org/
- Wildlife Conservation Society Climate Adaptation Fund – http://programs.wcs.org/northamerica/climate-adaptation-fund.aspx
- The Conservation Fund – http://www.conservationfund.org/
- The Trust for Public Land – https://www.tpl.org/
- Marin Agricultural Land Trust – http://www.malt.org/
- Blue Source – http://bluesource.com/
- Finite Carbon – http://www.finitecarbon.com/
- TerraCarbon – http://terracarbon.com/
- Lyme Timber – http://www.lymetimber.com/
- The Climate Trust –
- Blue Forest Conservation – http://www.blueforestconservation.com/
- Carbon offset Registries
- Climate Action Reserve – http://www.climateactionreserve.org/
- Verified Carbon Standard – http://www.v-c-s.org/
- American Carbon Registry – http://americancarbonregistry.org/
- The Climate Registry – https://www.theclimateregistry.org/
- The Gold Standard – http://www.goldstandard.org/

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- Peter Stein, *Lyme Timber*
- Mary Scoonover, *Resources Legacy Fund*
- Rick Huffines, *Tennessee River Gorge Trust*

4. Funding for Urban Climate Resilience

Shelley Clark
Yale School of Forestry & Environmental Studies

"How is the funding for more resilient cities being used to expand investments in 'natural' or 'green' infrastructure?"

In the face of climate change, urban areas are especially vulnerable to severe precipitation events and increased temperatures. As populations shift to urban areas, cities are grappling with how to adapt to the changing climate to keep residents safe and maintain infrastructure. Both municipalities and urban land trusts are working in innovative ways to help create resilient cities.

This chapter describes some of the ways that funding for more resilient cities is being used to improve and expand "natural" or "green" infrastructure like green roofs, bioswales, coastal wetlands and similar techniques.

It begins with an introduction to the major climate-related issues faced by urban areas, namely around water (too much or too little) and temperature (more heat events). It then moves to a discussion of the benefits of natural areas, both environmentally, but also aesthetically and socially, as a way to help address those issues in cities.

This merger of diverse benefits can be used as a driver for increased investment in urban green spaces. This paper focuses on several major sources of funding available to urban areas to complete resilience projects: taxes and fees, regulatory requirements, grants, loans, and equity investments. The paper concludes by identifying some important questions in this area moving forward and providing lists of resources for readers who wish to delve further into the topic.

4.1 The Needs and Opportunities for Funding "Green Infrastructure" in Cities

4.1.1 Population Shift to Urban Areas

Humans are rapidly moving into urban areas—making the negative effects on cities of our changing climate of increasing concern. The figure to the right shows the shift in the world's urban and rural populations. As urban areas grow, ecologists and policy-makers are attempting to integrate natural and social science into problem solving for future issues brought on by climate change (Grimm et al., 2008).

Harnessing both public and private funding to combat these issues is necessary to cope with population growth in cites. Increased needs for new infrastructure, maintenance of aging infrastructure and responses to climate change will all be major financial stressors for cities into the future.

Changing Climates in Urban Areas

The changing climate is likely to cause increased severity and frequency of extreme weather patterns (EPA, "Understanding," 2016). Increasing extremes in precipitation (too much rain or too little) and temperature (heat waves and worsening air quality) are both current and future concerns.

Major issues for cities include:

- The need to protect both the quality and quantity of drinking water sources,
- increasingly vulnerable coastlines (due to increased severity of storms like Hurricanes Katrina and Sandy in the United States and super typhoons in Asia),
- Increased stormwater and flooding (urban runoff generates ten trillion gallons of polluted water each year) (Encourage Capital, 2016),
- Rising temperatures, and
- Reductions in air quality (McDonald, 2015).

Rising Temperatures Create Dangerous Conditions in Urban Areas

Rising temperatures are a growing problem in urban areas, as paved surfaces and a lack of vegetated areas generate urban heat island effects and are less able to regulate temperatures. Green infrastructure can help address rising temperatures in urban areas in two ways: by reducing the amount of heat absorbing materials (such as dark, impervious surfaces) and by emitting water vapor (Stratus Consulting, 2009).

A devastating example of the impacts of rising temperatures was the 1995 heat wave that killed over 700 people in Chicago. Unfortunately, instances of severe damage and death resulting from the changing climate are expected to worsen. Cities are especially susceptible to these issues as they are often home to large numbers of vulnerable populations.

Addressing Climate Issues with Green Infrastructure

Natural areas in cities can help address the negative effects of climate change in a number of ways. They can serve as buffers for rising tides and influxes of water. Further, green infrastructure can help moderate temperatures in urban environments (see Chapter 2 above).

The benefits of natural areas in cities are not merely environmental, but can also—if surrounding communities have effective access over time—include a range of other services, from aesthetic values, to recreational opportunities and improved physical and mental health among urban populations (McDonald, 2015). The major benefits of such "green" or "natural" infrastructure may include, but are not limited to:

- "Carbon sequestration,
- Urban heat island mitigation,
- Reduced energy demand in buildings,
- Improved habitat and ecosystem services,
- Improved air quality,
- Community revitalization,
- Flood mitigation,
- Improved urban agriculture opportunities, and
- Green jobs" (NYC DEP, 2016).

Incorporating green infrastructure into a city is often a better solution than only building traditional physical infrastructure (like concrete tunnels and pipes) because it (a) often costs less to construct and (b) provides this wide range of services to city residents.

Urban Resilience and Environmental Justice

Urban parks have considerable value as a form of green infrastructure, but their history of use in this arena highlights important questions of access and equality that are relevant to the land conservation community as a whole. Creating urban parks can be costly, and too often the funding and political will available for such work is unevenly allocated. In a recent California case study, The City Project found that wealthy, predominantly white communities were receiving over two thirds of the funding earmarked for park construction and revitalization under Proposition 84, while communities of color were receiving only 31% of that same pool. This is particularly striking because when regulatory oversight is in place to ensure that funding set aside for environmental justice work is appropriately allocated—as it was in Prop 84's sister-measure AB 31—the disparity vanishes.

The need for stronger advocacy for environmental justice is evident in the highest levels of the conservation world. The United States Commission on Civil Rights' report on EPA performance under several regulatory measures in place to ensure environmental justice concerns are met found many areas where the agency could improve its performance. Chief among these was more direct engagement with people of color, low-income communities, and other environmental justice communities in crafting and implementing policy. A 2013 LTA report affirms the need for land trusts to take more active steps to engage with environmental justice communities as well, noting that of over 1,400 land trust staff members surveyed, a striking 97% of them where white. Troublingly, while many tools exist to aid environmental organizations in pursuing better environmental justice policies (EJ Leadership Forum 2015), implementation of these readily available best practices seems to remain a rarity.

Stories of land conservation and environmental organizations meeting the needs of communities of color, low income populations, and other diverse constituents—like the Lookout Mountain Conservancy's visible and successful Howard Program—are exciting and attention grabbing. But, the fact that they remain exceptions to a rule of weak engagement in environmental justice works is a reality that needs to be remedied. Engaging with climate change offers an opportunity to address this issue head on, as environmental justice communities are likely to be disproportionately impacted by climate change (Garcia 2016), and thus could be powerful allies in the adaptation and mitigation work undertaken by land trusts and other conservation agencies.

For more information, visit:

https://www.tpl.org/services/climate-smart-cities

http://www.cityprojectca.org/blog/archives/32075

http://www.cityprojectca.org/blog/archives/43641

http://www.cityprojectca.org/blog/archives/43798

http://www.landtrustalliance.org/publication/2013-land-trust-salaries-and-benefits-survey-summary-report

http://lookoutmountainconservancy.org/latest-news/hill-howard-built/

Urban land trusts can play an important part in the implementation of green infrastructure. Urban green space provides many of the benefits that can help address the environmental problems brought on by climate change. Thus, changing the way we think about parks from their recreation and aesthetic value to also include the ecosystem services they provide is increasingly a part of planning for the future of cities. Land trusts can combine the different sources of funding discussed below to help create green infrastructure projects. Urban land trusts can also partner with municipalities and other community organizations to explore whether and how using green infrastructure might help them achieve their overlapping goals.

Highline Park, New York, New York

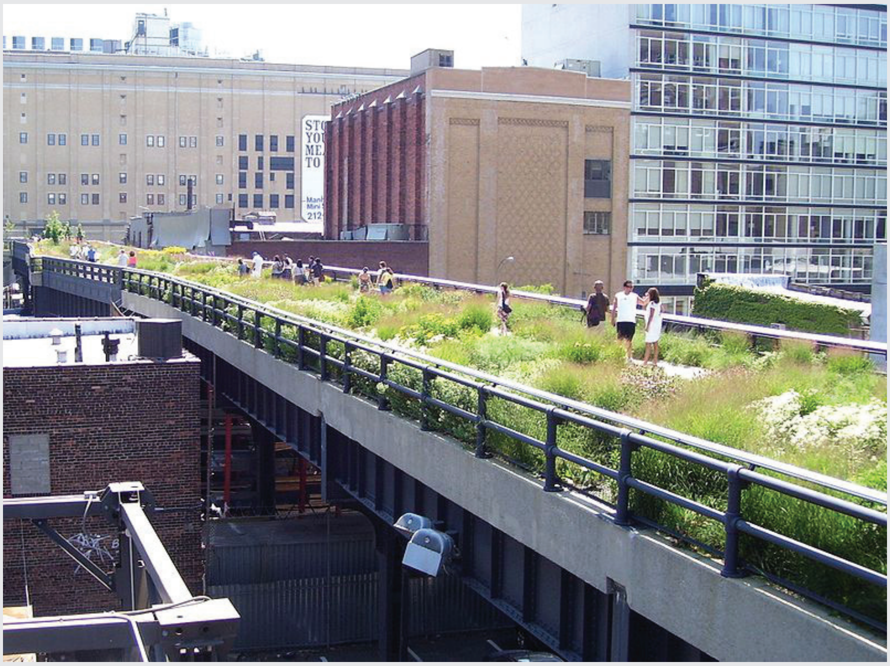

Photo of Highline Park in New York City, Wikipedia photo credit Beyond My Own Ken, published and attributed with permission of photographer under GNU Free Documentation License.

For more information, visit:
http://www.thehighline.org/

4.1.2 Using Green Infrastructure to Help Address Stormwater Issues

Solving issues pertaining to stormwater is an example of an area where the installation of green infrastructure is succeeding. Stormwater runoff is the principle cause of pollution in urban waterways (Valderrama and Levine, 2012). When large storm events occur in cities that are subject to flooding, wastewater flows can exceed the capacity of sewer systems. In a combined sewer system, the excess water (including both storm water and untreated sanitary waste water) goes directly to surface water bodies. These overflows, called combined sewer overflows, are a major source of water pollution (EPA, "Combined Sewer Overflows"). Even in cities that use separated sewers, urban runoff contains high levels of pollutants from cars, pets, garbage, and many other sources.

As precipitation events become more severe, urban flooding is a concern for many cities. Water quality management techniques like rain gardens, permeable pavement, and green roofs mimic natural hydrological functions to capture and filter storm water before it reaches the sewer system (NRDC, "Encourage," 2016).

The Clean Water Act Driving Investments in Urban Stormwater

Under the Clean Water Act ("CWA"), the Environmental Protection Agency regulates the water that cities discharge into waterways. Complying with the CWA gives cities a strong incentive to deal with issues of stormwater in effective ways (Valderrama and Levine, 2009). Nearly 800 communities in the US have obligations to reduce combined sewer overflows under the mandate of the CWA, not to mention the cities that have separated sewer systems that must also come into compliance. Green infrastructure often offers a cost effective way to meet a portion of cities' efforts to come into compliance (ASLA et al. 2012).

The City of Philadelphia is using green infrastructure as part of its plan to meet the requirements of the CWA by controlling its combined sewer overflows. The city has announced a $1.6 billion plan to transform the city and embrace stormwater retention.

Measuring the monetary benefits of green infrastructure is an important first step in integrating these innovative techniques into urban areas. At the same time, Philadelphia is focusing its efforts on green infrastructure not only to deal with stormwater, but to provide other benefits to communities and ecosystems as well.

The techniques that are used to deal with stormwater can also help alleviate rising temperature impacts. This paper uses stormwater solutions as an example of successes in green infrastructure. For a more in depth discussion of strategies to combat rising temperature impacts (such as white roofs), see Chapter 2 above.

4.1.3 The Potential Downsides of Green Infrastructure

Although green infrastructure offers a multi-benefit option for helping to address climate change impacts in urban areas, there are several possible downsides of green infrastructure projects. For instance, creating green space in urban areas tends to make neighborhoods more desirable, hence more expensive. This can lead to the displacement of low-income residents as rents are raised around parks and green spaces (Wolch, et al., 2014).

Another issue is the newness and innovation that comes with new green infrastructure projects. Although green infrastructure projects offer multiple benefits, city planners and engineers know less about how green infrastructure installations will work at large scales, as compared to more traditional engineering fixes. They can also require more regular maintenance than some "grey" infrastructure approaches.

Finally, in some redevelopment and retrofit settings, green infrastructure may have higher installation costs.

4.2 Possible Sources of Funding

Cities, investors, and others are addressing resilience financing and stewardship of natural spaces in urban areas in a wide variety of ways. This paper focuses on several major sources of revenue and investment capital available to urban areas to complete resilience projects, including: municipal revenue streams and programs for paying for green infrastructure, grants, and loans or equity investments.

n expenses) year on year after the reductions have been verified by a third party. Offset developers and sellers can sell multiple years' worth of credits up front, though this of course means that they incur some level of risk should the project fail. If a land trust wants to use the money for stewardship, it can use funds received up front to start an endowment, or it can incorporate projected revenues from annual carbon sales in its annual operating budget.

4.2.1 City Revenues/Incentive Programs for Financing Green Infrastructure Services

To pay for most infrastructure projects, cities have two major sources of revenue: tax revenues and user fees (such as drinking water or stormwater fees). These streams of revenue also allow municipalities to borrow money, as discussed below, and pay investors back. In addition, regulatory requirements for new developments can create incentives for private investors in stormwater infrastructure. Financing green infrastructure projects in cities depends on making the connections between the benefits the infrastructure provides and those who are paying for those benefits.

Green Infrastructure Programs

The Environmental Protection Agency outlines five main types incentive programs that allow cities to encourage investment in green infrastructure:

1. Development incentives
2. Grants from cities to private property owners
3. Rebates and installation financing programs
4. Awards and recognition programs
5. Stormwater fee discounts (Water Environment Federation, "New York City," 2016)
6. These tools allow cities to incentivize investments in green infrastructure.

New York City has extensive work underway in green infrastructure. In 2010, the city released its NYC Green Infrastructure Plan. The Plan anticipates using green infrastructure "to optimize the existing system and to build targeted, cost-effective 'grey' or traditional infrastructure" (NYC DEP, "Green Infrastructure Plan," 2016).

This year's annual report detailing the progress and status of projects showed a twenty percent decrease in water flows into sewers in three Brooklyn neighborhoods where green space near sewers was installed (Water Environment Federation, "New York City," 2016).

Much of this work is financed through the issuance of bonds which are paid back through user fees and/or taxes (see discussion below).

Several cities, including Philadelphia, are addressing water quality issues through stormwater fee programs. These programs encourage land owners and developers to design and locate projects in a way that reduces their impacts on water resources — see box below.

Philadelphia's Stormwater Fee Program

Philadelphia requires non-residential property owners to pay a fee for stormwater. The city created a parcel-based stormwater billing structure. Non-residential owners who can demonstrate onsite management of the first inch of rainfall over their entire parcel can get a credit for nearly all of their stormwater fee (Valderrama and Levine, 2012). This creates an incentive for property owners to deal with stormwater onsite and decrease runoff into a combined sewer system.

Philadelphia's work on stormwater incorporates a wide range of green infrastructure techniques — as shown in the diagram below.

Philadelphia Water Dept.

Washington, D.C. has gone even further and adopted new building code provisions to increase the amount of runoff that must be managed by private property owners. As one way to meet those requirements, the city also created a stormwater credit trading program. Under this program, private property owners can receive stormwater credits for installing green infrastructure and then sell those credits to others needing to meet the retention requirements. This allows the District to create potentially attractive equity investments in managing stormwater runoff (see box below and discussion later in this chapter).

Investment in Stormwater Management in Washington, D.C.

Prudential Financial recently invested $1.7 million in a collaboration between TNC NatureVest and Encourage Capital to install new green infrastructure facilities in D.C. This pilot project, District Stormwater LLC, is intended to support the Stormwater Retention Credit trading program launched by the District in 2013 (NatureVest, "Stormwater," 2016). Under that stormwater regulatory program, developers of new projects can meet up to fifty percent of a project's regulatory requirement off-site through the purchase of such stormwater retention credits (Encourage Capital, 2013).

Because of the need for large, up-front capital investments in many green infrastructure projects, cities usually cannot bear the burden alone with currently available municipal resources. Fortunately, in a recent survey, NatureVest and EKO Asset Management Group found that private investors hope to deploy $5.6 billion in conservation impact investments in the next five years – some portion of which may well be available to fund green infrastructure projects in cities (NatureVest and EKO, 2014). The following sections of this paper discuss these opportunities to bring in outside sources of funds, including both grants from public and private entities, as well as loans and equity investments.

The Trust for Public Land's Climate Smart Cities Initiative

The Trust for Public Land (TPL) is working with municipalities to bring together sources of funding to complete green infrastructure projects. TPL's Climate-Smart Cities initiative is focused on helping cities create parks and conserve land to combat the negative impacts of climate change through four objectives:

1. "Connect: Trails and transit lines provide carbon-free transportation and link residents to popular destinations and each other.
2. Cool: Shady green spaces reduce the urban "heat island" effect, protect people from heat waves, and reduce summer energy use.
3. Absorb: Water-smart parks, playgrounds, and green alleys absorb rainfall, reduce flooding, and recharge drinking water supplies while saving energy for water management.
4. Protect: Shoreline parks and natural lands buffer cities from rising seas, coastal storms, and flooding."

(TPL, "Climate-Smart Cities," 2016).

4.2.2 Grants from Public and Private Entities

Grants to help support the installation of green infrastructure projects are available through both public and private institutions.

For instance, Connecticut recently received a $54 million grant from the Department of Housing and Urban Development through its National Disaster Resiliency Competition to improve shoreline infrastructure and increase resiliency (State of Connecticut, 2016). The project includes installations of bioswales to address flooding and mitigate the impacts of stormwater runoff into cities' storm sewer systems (Connecticut, 2016).

Other grants are available from federal agencies, including but not limited to the Department of Energy, the Department of the Interior, the Department of Transportation, the National Oceanic and Atmospheric Administration, the Department of Agriculture, the Economic Development Administration, and of course the Environmental Protection Agency (EPA, "Green Infrastructure," 2016).

Private foundations are also a source of grant money for municipalities or urban land trusts. One example that focuses specifically on climate change projects are the Kresge Foundation's Climate Initiative and Urban Opportunity Initiative. The Foundation states that it plans "to strengthen the climate-resilience field by supporting new models and methodologies that directly benefit low-income communities" (Kresge, 2016). The Kresge Foundation is addressing not only climate resilience head-on, but also focusing on environmental justice issues. Planning for and acknowledging problems of vulnerable populations in urban areas should be an integral part of climate resilience planning.

Foundations are also making information and other resources available to municipalities to help them plan for resiliency. For instance, the Rockefeller Foundation's 100 Resilient Cities Program provides both financial and knowledge-based resources for cities (100 Resilient Cities, 2016). This expert support is intended to help in the "development of a robust resilience strategy" for cities.

4.2.3 Loans and Equity Investments in Green Infrastructure Projects

The final methods of financing discussed here are borrowing money and attracting equity investment, as both require that the funds received be paid back with interest and/or at a profit.

Concessionary, public debt may be available for green infrastructure projects through "State Revolving Loan Funds." For example, in 2009, President Obama enacted the American Recovery and Reinvestment Act "that provided $6 billion for clean water and drinking water infrastructure through the State Revolving Fund." Twenty percent of the water infrastructure funding was specifically slated for green infrastructure, encouraging efficiency and environmental innovation (EPA, "Getting to Green," 2016).

When a project requires too much capital to finance through current use municipal funds, grants, or public lending programs, sales of municipal bonds can help bridge the gap to completing projects. Bondholders generally view municipal debt as low-risk activities, as cities typically have large tax bases and a track record of paying back loans (Federal Reserve, 2016).

After a city takes on debt to complete a project, it must find the cash flows to pay back the loan. Loans are repaid "through general cash flows or through specific revenue streams, such as water and sewer fees or stadium and parking fees" (Federal Reserve, 2016). Baltimore, for instance, is using stormwater fees to pay back private loans (Water Environment Federation, 2016). Real estate taxes are also a common revenue source used to pay back large infrastructure loans.

Green Bonds/Debt for Conservation Investments

Another option for financing green infrastructure projects in urban areas is green bonds. Green bonds are a specific type of loan that can be used for projects with an environmentally-friendly or climate focus (Climate Bonds Initiative, 2016). The Climate Bonds Initiative predicts the market for green bonds will grow exponentially to $100 billion in 2015. Issuers range from multilateral and bilateral entities like the World Bank, to government agencies, municipalities and corporations (NatureVest and EKO, 2014). Credit Suisse has also looked more widely at how businesses might use debt for investments in ecosystem services (Credit Suisse, 2016).

Opportunities for equity investors can also be created around contracts to provide services or goods to city governments, regulated entities (such as property developers in Washington, D.C. as described above) or other service users (such as water utilities).

As noted above, a growing number of investors are interested in conservation impact investments. Major areas of impact investing include sustainable food production, habitat conservation and water quality/quantity conservation (NatureVest and EKO, 2014). The issues urban areas face from increased precipitation could certainly fit into the third of these categories.

Through equity investments, investors fund projects intended to return principle or generate profit while also driving a positive impact on natural resources and ecosystems. For instance, entities like NatureVest are working to catalyze markets for stormwater credits and to supply funds for stormwater retention infrastructure.

As cities create incentives like stormwater credit programs to adapt to the changing climate, there are opportunities for private entities to invest in helping them do so.

Conclusion

As we increasingly understand the services natural areas and green infrastructure provide, increased demand for those services should lead to expanded sources of funding. Cities can benefit from creating economic and regulatory incentives for private parties to invest in innovative green infrastructure techniques. As cities work to address the impacts of a changing climate, innovative solutions using science-backed green technologies can help address problems like increased stormwater runoff and rising temperatures. Investments in green infrastructure will become more attractive as the connections between natural areas and the services they provide become clearer.

Directive from the White House Pushes a Consideration of Ecosystem Services

Earlier in 2016, the White House issued a directive to push federal agencies to incorporate ecosystem services valuation in their plans, investments, and regulations. This move towards acknowledging the monetary benefits provided by green spaces in addition to the aesthetic, social, and recreational benefits they provide is an important step towards creating a market for investors.

For more information, visit:

http://www.conservationfinancenetwork.org/2016/01/12/white-house-values-societal-benefits-ecosystem-conservation

Provided below is a list of possible questions for discussion and lists of resources on the topic of green infrastructure finance in urban areas.

Possible Questions for Discussion

- What are the barriers to attracting more investment in green infrastructure in cities – either in their traditional planning processes or sources of finance?
- What other innovative incentive programs besides stormwater fee and credit programs might municipalities develop to harness third-party investments in green infrastructure?
- How can urban land trusts better help harness funds from grantors and third-party investors for green infrastructure projects?
- How do environmental justice issues fit into the discussion of green infrastructure? Does encouraging green space also encourage gentrification and pricing communities out of their own neighborhoods? If so, how should it best be addressed?

Some of the Organizations Doing Interesting Work on this Topic

- **NYC's Green Infrastructure Plan:** The New York City Department of Environmental Protection issues a yearly report on the city's progress in instituting green infrastructure projects. http://www.nyc.gov/html/dep/pdf/green_infrastructure/gi_annual_report_2015.pdf.
- **US Environmental Protection Agency:** The EPA offers a plethora of information on financing green infrastructure projects on their website. Additionally, in 2014, the Agency put out a report entitled "Getting to Green: Paying to Green Infrastructure, Financing Options and Resources for Local Decision-Makers" available at: http://www.epa.gov/sites/production/files/2015-02/documents/gi_financing_options_12-2014_4.pdf.
- A Triple Bottom Line Assessment of Traditional and Green Infrastructure Options for Controlling CSO Events in Philadelphia's Watersheds. Prepared for the City of Philadelphia by Stratus Consulting.
- The City of Philadelphia commissioned a consultancy to create this report to access the green infrastructure approach as it grapples with an influx of stormwater. The report details the benefits of using green infrastructure (instead of traditional engineering large physical infrastructure projects) and compares costs.
- **"Financing Stormwater Retrofits in Philadelphia and Beyond." Natural Resources Defense Council:** This report addresses the issues with bridging the gap between private funders and stormwater infrastructure investments. The paper gives recommendations for how public and private actors can promote private investments in stormwater retrofits.

- **Trust for Public Land:** TPL is a leader in combining sources of funding to create green infrastructure projects in urban areas. Through its Climate-Smart Cities program, the organization is partnering with cities like Los Angeles, California, New York, New York, and Seattle, Washington.
- **William Penn Foundation in Philadelphia:** The William Penn Foundation works to protect the Delaware River watershed in the Philadelphia area. The Foundation works in rural areas and urban centers. The Foundation recently gave the city $1.5 million for a new bike share program as part of the watershed protection campaign.

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Biosketches of Authors

Bradford S. Gentry is the Associate Dean for Professional Practice at the Yale School of Forestry & Environmental Studies, a Professor in the Practice at the Yale School of Management and Director of the Yale Center for Business and the Environment. Trained as a biologist and a lawyer, his work focuses on strengthening the links between private investment and improved environmental performance. He has worked on land, water, energy, industrial and other projects in over 40 countries for private (GE, Suez Environnement, Working Lands Investment Partners), public (UNDP, World Bank, Secretariat for the Climate Change Convention) and not-for-profit (Land Trust Alliance, The Trust for Public Land) organizations. He holds a BA from Swarthmore College and a JD from Harvard Law School.

Shelley Clark is a native of Florence, Mississippi. She graduated from the University of Mississippi in 2011 with a B.A. in international studies and French and a minor in environmental studies. After graduation from Ole Miss, she moved to Denver, Colorado to enjoy the scenic beauty of the Rocky Mountains before continuing her studies. After spending a year adventuring in Denver, she moved to New York City to begin her studies at Pace Law School. After two years of legal study at Pace, she began a joint-degree program with the Yale School of Forestry & Environmental Studies in New Haven, Connecticut to delve deeper into the study of environmental law and hone analytical skills. She graduated from the joint-degree program in May of 2016 with a Juris Doctor from Pace Law and a Master of Environmental Management from F&ES. At Pace and F&ES, she focused her work and studies on land use law, from the study of private conservation to zoning regulations. Upon graduation, she moved to Berkeley, California where she lives now. She works at The Chanler Group in Berkeley, a law firm that enforces regulations that limit toxic chemicals in consumer products through civil litigation. She enjoys reading, traveling, crafts, yoga, and hula-hooping.

While growing up in San Francisco, **Colin Kelly** swore to himself that he would not spend his life working at a desk in a tall building. He attended Colorado College for undergrad, spent four summers and one winter as a guide and commercial fisherman in Alaska, and has climbed up and skied down mountains in Alaska, Colorado, Mexico and Bolivia. His passion for the natural world led him to climate change advocacy and then, inevitably, desks in tall buildings. He spent two years supporting the launch and build out of the Shakti Sustainable Energy Foundation in New Delhi and three years as a Senior Program Associate at ClimateWorks Foundation in San Francisco, helping manage the organization's Power, Climate Policy and Forest and Land Use portfolios. He spent two years in New Haven pursuing his Master's at the Yale School of Forestry and Environmental Studies, where he focused on conservation, finance, and climate change. He is now happily back at his desk at ClimateWorks where he is managing a project to mobilize vastly more philanthropic capital behind climate change solutions.

Joshua Morse is a Massachusetts native, who grew up exploring several thousand acres of public and private conservation land behind his parents' home in the Berkshires. His early experiences fishing, hiking, and birding this land inspired a life-long interest in conservation that led him to serve as an AmeriCorps volunteer with the MassLIFT program, to work as a land steward with the Franklin Land Trust, and eventually to return to school for a masters in environmental science at Yale F&ES. In addition to his involvement with the Berkley Workshops, Joshua has studied how social forces shape wildlife conservation in the American West and worked with the Yale School Forests to assess the potential for a landscape scale conservation project surrounding the Yale Myers Forest in eastern Connecticut. After graduating from F&ES, Joshua will continue to work at the intersection of natural resources and society as a doctoral candidate at the University of Vermont's Rubenstein School, and holds a B.A. in Biology from Oberlin College. In his free time, Joshua enjoys contra dancing, bluegrass music, and exploring the woods with his dog Pepper.

Yale Program on Strategies for the Future of Conservation
Bradford S. Gentry, Director

The purpose of the Yale Program on Strategies for the Future of Conservation is:

- To support the efforts of the Maine Coast Heritage Trust, the Land Trust Alliance and similar private organizations to develop and apply new, innovative strategies for land conservation by linking the convening, research, and teaching activities at the Yale School of Forestry & Environmental Studies ever more closely to the needs of the land conservation community.

Established by a gift from Forrest Berkley '76 and Marcie Tyre, the Program has two parts:

- Sponsoring student internships and research projects (through the Berkley Conservation Scholars program), to bring the passion, experience and creativity of Yale graduate students to bear on these issues; and
- Convening workshops and other conversations across sectors and perspectives in the search for new approaches to expanding the resources applied to land conservation in the United States.

Berkley Conservation Scholars are students of high potential who receive funding for their research and professional experiences at the cutting edge of land conservation. Support is available during both the school year and the summer, creating a virtual "R&D Department" for the U.S. land conservation community. The Berkley Conservation Scholars play a critical role in helping to bring together practitioners and academics in the search for new conservation tools.

The Yale Program on Strategies for the Future of Conservation is a major extension of the Yale School of Forestry & Environmental Studies' continuing efforts to enhance the effectiveness of land conservation. Working with an advisory group of land conservation leaders, the program hosts workshops, training programs and other activities around the themes of engaging new communities in conservation, expanding the conservation toolkit, and ensuring the permanence of conservation gains.

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