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Quality of urban forest carbon credits

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ABSTRACT

While the urban forest is considered an eligible source of carbon offset credits, little is known about its market potential and the quality aspects of the credits. As credit suppliers increase in number and credit buyers become more interested in purchasing carbon credits, it is unclear whether and how urban forest carbon credits can perform relative to the other types of carbon credits available in the market. Delivering quality credits would be crucial especially in voluntary markets such as the U.S., where buyers are more likely to be committed to reducing their GHGs emissions and maintaining a positive public image, than just abiding by regulations. Utilizing the results of a nationwide survey of local governments, this study takes a first step toward evaluating the quality aspects of urban forest carbon credits. We conclude that the local municipalities and cities in the U.S., acting as sellers of carbon credits, have the resources and capacity to be competitive in carbon credit markets. In addition, they have capacity and resources to implement carbon projects that will meet the key quality criteria (e.g., additionality, permanence, and verification).

Introduction

Today, global warming is a major environmental concern. According to the Intergovernmental Panel on Climate Change (IPCC, 2007), eleven of the twelve years from 1995 through 2006 observed the warmest global surface temperature since 1850. In response, several initiatives have been undertaken to reduce the effect of increasing atmospheric greenhouse gasses (GHGs) concentrations. For example, the Kyoto Protocol, a global-scale initiative under the United Nations Framework Convention on Climate Change (UNFCCC), calls on industrialized nations to establish a legally binding commitment to reduce GHGs emissions. The European Union Trading Scheme (EU ETS) is an example of a mandatory, Kyoto-based cap and trade program. The Regional Greenhouse Gas Initiative (RGGI) is a regional mandatory cap-and-trade program to help northeastern U.S. states reduce their GHGs emissions. It is a cooperative emission trading scheme to reduce carbon emissions through a multi-state cap and trade program.

There are also numerous local and regional initiatives to promote voluntary GHGs emissions reductions, which emerged to meet demand where regulation is absent. The Chicago Climate Exchange (CCX) and California Climate Action Registry (CCAR) are examples of such initiatives in the U.S., which at this time does not have federal mandatory carbon emissions regulations. CCX is a platform to facilitate member based exchange of voluntary emission reductions where companies that fail to reduce their own emissions purchase from other members with extra emission reductions or buy from verified offset projects.

There are remarkable differences between voluntary initiatives being practiced in the U.S. and programs implemented in other countries under the Kyoto Protocol. The emission reduction credits that are certified and traded under the Clean Development Mechanism of the Kyoto Protocol are designed strictly in accordance with Kyoto Protocol's monitoring, verification and certification processes, whereas offset credits traded in voluntary markets in the U.S. are not, and, as a result, are not traded in overseas markets.

With growing public awareness of environmental issues worldwide, a number of national governments have tightened their environmental regulations with respect to GHGs emissions (Bayon et al., 2009; FAO, 2011). This may cause GHGs emitting companies to either cease operations in the future, or comply with the new regulations by reducing emissions (Hufbauer et al., 2009). However, buying carbon emission credits is often cheaper and more efficient for companies than reducing their own emissions. Under mandatory regulations in place, programs such as cap and trade provide a certain number of emission allowances to emitters every year and they can either pollute up to the cap, or adopt alternative practices to reduce emission and thereby sell the remaining credits to others with emission levels exceeding the cap.

In case of the U.S., however, there is no blanket federal mandatory regulation in place as of now. So, the carbon credit trading in emerging market platforms like CCX are motivated by voluntary

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efforts of individual companies and businesses interested in promoting their green image, showing environmental responsibility and taking innovative actions to hedge against future regulations. Therefore, the demand for carbon credits in such an unregulated market is driven more by the interests and voluntary efforts of individual companies to take environmental responsibility and maintain corporate image. Such businesses may value the quality of the credit highly as they are concerned about the environment and social welfare. CCX has provided opportunities for companies to offset their emissions by purchasing credits from sellers who capture and store atmospheric carbon. CCX alone registered more than 26 million metric tons of carbon credits in 2009 (Chicago Climate Exchange, 2009).

Carbon sequestration through forestry projects is considered a widely recognized method to reduce atmospheric GHG concentration (Sedjo et al., 2001; Bigsby, 2009). Trees, through the process of photosynthesis, absorb atmospheric carbon and store it in biomass and soils. Worldwide, forests sequester about a quarter of global atmospheric carbon annually emitted though fossil fuel combustion (Wofsy, 2001). Looking at the market side, carbon credits from forestry projects accounted for about 7 million metric tons at CCX in 2008, making forestry the second largest source of carbon credits in the CCX registry. Currently, the five types of forestry projects recognized in carbon markets are afforestation, reforestation, avoided deforestation, intensive forest management, and urban forestry.

Emerging literature has attempted to answer numerous questions about carbon sequestration in urban forests. Several studies addressed the measurement and quantification of carbon sequestration in urban trees (Birdsey, 1992; Jo and McPherson, 1995; Hoover et al., 2000; Nowak and Crane, 2002; Myeong et al., 2006; Pouyat et al., 2006; Smith et al., 2004, 2006), as well as the evaluation of ecological and other benefits (Rowntree and Nowak, 1991; McPherson, 1994, 1998; Jo and McPherson, 2001; Brack, 2002). Although the literature on marketing of other types of forest projects has grown in recent years, little is known about the market potential and quality criteria of urban forest carbon credit projects.

Credit quality in carbon trading

The quality of a carbon offset project is defined by a variety of criteria. For example, the quality of a credit from forestry projects depends on project's ability to sequester and permanently store carbon, whereas in a wind energy project, it depends on project's ability to prevent emissions that would have been otherwise released into the atmosphere. Because there are a myriad of carbon project types currently recognized, the quality of credits that these projects generate varies greatly. Some offset projects are considered high quality because it is possible to demonstrate with established scientific methods that they offer real emission reductions benefits, while others are considered high quality because some rigorous verification criteria can be applied to establish whether the credits are permanent.

Researchers argue that nascent carbon credit markets suffered from a serious limitation because credit marketing was given priority over credit quality (Tansey, 2009). Moreover, the initial period of credit market emergence in North America (2003–2006) lacked reliable and tested techniques and quality review methods to ensure the quality. As a result, low quality credits were traded, and in many cases carbon projects merely represented business as usual (Tansey, 2009). Today carbon markets rely on a number of rigorous standards and independent verification mechanisms to examine whether carbon credits represent real reductions in GHGs emissions. Demand for quality credits is likely to grow in voluntary markets like the U.S. Companies that are currently voluntarily participating in GHGs reduction schemes may well value public image, corporate responsibility, and leadership in innovation. Therefore, such companies would likely be interested in high quality credits that represent real reductions in GHGs emissions.

According to a recent report by the U.S. Government Accountability Office, more than 600 organizations develop and sell carbon offsets within the U.S. (GAO, 2008). Since voluntary markets in the U.S. are largely unregulated, different carbon providers use different techniques to generate, measure and market the credits. This can create a remarkable variation in the quality of credits offered. At the same time, credit buyers are looking for vendors that sell high quality credits. For example, a recent survey of offset buyers indicated that buyers increasingly prefer high quality carbon credits representing emissions reductions that are real, additional, verifiable, permanent, and unique (ENDS Carbon Offsetting Survey, 2009). In a recent survey of forest carbon credit buyers worldwide, Neeff et al. (2009) found that the quality standard of carbon credits is the most important factor for prospective purchasers. The U.S. government also promotes trading of high quality credits. For example, Section 734 of the American Clean Energy and Security Act of 2009 establishes various provisions to ensure that emission reductions represented by carbon credits are real, additional, measurable, and verifiable.

As buyers who are interested in high quality credits have difficulties in finding acceptable credit suppliers (Carbon Concierge, 2008), a number of non-profit and for-profit organizations have published consumer guidelines and technical reports to advise buyers how to thoroughly evaluate carbon credits. For example, Clean Air-Cool Planet (2006) prepared a consumer guide to selecting carbon credit providers. It presents a detailed description of what makes a high quality credit and discusses evaluation criteria relevant for ranking retail credit providers. A similar report by Offset Quality Initiative (2008) suggested a list of key quality criteria for credit evaluation. It also categorized carbon credit projects based on their GHGs reductions methodology. Similarly, Carbon Concierge (2008) developed a criteria-based matrix to evaluate the quality of carbon credit providers, while Beane et al. (2008) developed a scorecard for evaluating the quality of forest carbon credits. The scorecard contains a series of yes/no questions assessing eight general quality components. Together, these initiatives clearly indicate that the market is growing for high quality credits and therefore projects that cannot meet these quality criteria may have limited marketing scope in the future. It is in this context that our paper examines whether and how urban forest carbon offsets meet quality criteria.

Urban forests potential to supply carbon credits in the U.S.

Urban forests in the U.S. consist of trees in the streets, parks, riparian buffers, and other public as well as private areas. A study by Nowak and Walton (2005) estimated that urban land use in 2000 constituted slightly more than 3% of the total land area and projected that its share will grow to 8% by 2050. Nowak et al. (2001) suggested that average tree coverage in urban areas in the U.S. is slightly less than a third (27%) and that there are 4 billion urban trees in the U.S. Bratkovich et al. (2008) claimed that another 70 billion trees are growing in metropolitan areas nationwide.

Recent studies have examined carbon sequestration and storage capacities of urban forests. For example, the amount of carbon sequestered annually in urban forests in the lower forty-eight states is estimated at about 22.8 million tons (Nowak and Crane, 2002). They also estimate the total carbon storage capacity at 700 million tons for the coterminous U.S. An earlier study by Nowak (1994) had estimated the total carbon storage capacity of urban forests in the U.S. could be as high as 900 million tons.

It should be noted, however, that the real potential of urban forestry to produce additional carbon sequestration will depend both on the existing stock and full potential stock. Available literature and data on urban forestry carbon does not provide a clear estimate of full potential stocking. A number of studies, including Nowak and Crane (2002) highlight the current carbon storage and potential annual sequestration rates in major metropolitan areas in the U.S. Given the unprecedented rate of growth in the urban share of the land (Nowak and Walton, 2005), more areas are expected to be available for establishing new urban forestry projects in future in the form of new plantations on marginal land, and land acquisition for urban parks and public open space.

Local governments, including cities and municipalities, have shown interest in carbon credit trading. For example, the U.S. Conference of Mayors Climate Protection Center was established in 2007 to help cities in mitigating and reducing the impact of global warming. The Center currently has more than 1000 members, who are committed to reducing their GHGs emissions through various land use management actions and bi-partisan campaigning to establish a national emission trading system. In addition, a dozen local governments including eight municipalities, three counties, and two states have already enrolled in the CCX trading program. Hence, even in the absence of federal regulation, market potential exists.

There are numerous approaches and methodologies to estimate the amount and value of carbon sequestered by urban trees. However, we know little about the quality of carbon credits from urban forest projects. This study addresses this gap by analyzing responses from a recent survey of local governments in the U.S. in which the quality aspects of urban forest carbon credits are discussed. Specifically, study objectives are: (1) identifying the key quality criteria for carbon credits already recognized in the market, and (2) analyzing whether and how urban forest credits meet these criteria.

Procedure and methods

This study was completed in three phases. The first phase involved reviewing the available literature including journal articles, technical reports, and user guidelines developed by carbon trading organizations and non-profit organizations to identify widely accepted quality criteria currently being used in carbon trading. Another phase involved analyzing the responses from a nationwide survey of local governments to assess if they have information, resources, and capacities relevant in demonstrating credit quality. The third phase involved interpretation and an analytical discussion of survey results against the key quality criteria.

Survey of local governments

A web-based nationwide survey was designed and implemented between November 2007 and January 2008 to determine the motivations and ability of cities and municipal governments to participate in carbon markets. Urban foresters, arborists, and other individuals responsible for the management of urban trees were identified and invited to participate in the survey. Contact information was obtained from the Society of Municipal Arborists.

The survey asked respondents about their current urban forest information and management practices, including the types of forests they manage, details of available tree inventory, the presence of a staff forester, and/or the existence of an urban tree management or risk management plan. Questions were also asked to assess current interests and activities of local governments in climate change mitigation efforts and participation in voluntary carbon reduction schemes. Survey questions used a range of formats including categorical, open-ended, and Liker-type scales (Likert, 1932). Out of the total 299 surveys distributed, 22 were undeliverable or had wrong addresses. A total of 150 completed surveys were returned yielding an effective overall response rate of 54%. Respondents were uniformly distributed in terms of a city size. More details on the survey implementation and data collection can be found in Poudyal et al. (2010).

Results and discussion

Carbon credit quality criteria

A review of published articles and technical reports indicates that several criteria have been developed and widely used to assess or discuss credit quality. While some disagreement persists, most agree on a set of common standard criteria. The Tufts' Carbon Initiative suggests that a high quality credit should clearly demonstrate additionality, avoid double counting of credits, have a realistically calculated baseline and emission reduction projections, account for leakage, and be permanent (Kollmuss and Bowell, 2006). The American Clean Energy and Security Act of 2009 requires the credit to be real, additional, measurable, verifiable, permanent, transparent, and has no-leakage. Clean Air-Cool Planet (2006) also included credit cost and ancillary environmental benefits in credit quality criteria in addition to additionality, baseline, benefit quantification, permanence, ownership, monitoring and verification, and registration.

Beane et al. (2008) used eight components of carbon credit projects to examine their quality. These include contract structure, baselines, additionality, monitoring and verification, permanence, leakage, transparency, and co-benefit/costs. In addition to other criteria commonly used, they also consider potential ancillary benefits of the project to society as an evaluation criterion. Offset Quality Initiative (OQI), which is a collaborative, consensus based effort of six leading non-profit organizations in climate change sector (The Climate Trust, Pew Center for Global Climate Change, Climate Action Reserve, Environmental Resources Trust, Greenhouse Gas Management Institute, and the Climate Group), suggested nine key criteria to evaluate the offset quality. It recommends that the credit should be real, additional, based on a realistic baseline, quantified and monitored, independently verified, unambiguously owned, address leakage and permanence, and do no net harm (Offset Quality Initiative, 2008). Likewise, Carbon Concierge (2008) suggested regionality as another criterion, which requires that the emission reduction projects be located within the region of emission source. In sum, there is a general agreement among these studies on most criteria, which are likely reliable indicators of credit quality. Based on this review, we used a set of quality criteria recommended by Quality Offset Initiative and few additional criteria suggested by other sources in evaluating the quality of urban forest carbon credits. Those criteria are presented in Table 1 with short descriptions and their sources.

Survey responses

Respondents answered questions about urban forest information availability and management and carbon sequestration issues. For example, when asked about the person responsible for the management of municipality's urban forest, 95 out of 155 respondents indicated that there was an official primarily responsible for the management of urban trees. Moreover, surveyed cities indicated that they have an official urban forester or arborist (85 responses), or that urban forests are overseen by heads of other departments such as parks (6) and public works (3), or by a consulting forester or arborist (1). When asked about the type of urban forest trees, 90% of respondents indicated that their cities own and manage trees along

Table 1
Key credit quality criteria.

Criteria	Description	Source
Additionality	Additionality requires the emission reduction created by the project should be additional to what would have happened in the absence of project	A, B, C, D, E, F, G
Baseline establishment	Baseline refers to a realistically established pre-project emission level or emission reduction capacity, against which the contribution of offset project can be measured	A, C, D, F, G
Real	It requires the offset to represent the real or actual emission reduction from the atmosphere	A, B
Quantification and monitoring	This criteria requires for a unique plan with clear statement of methodological, personal and locational detail of quantifying the emission reduction	A, B, C, D, F, G
Verification	Verification requires the feasibility of independent verification of claimed offset credits by a third party	A, B, D, E, F, G
Ownership	Ownership refers to an unambiguous definition of project ownership and right to sell the offset	A, C, D, G
Leakage	Leakage requires the avoidance of possible shift or increase in emission as a result of a offset project	A, B, C, D, F
Permanence	Permanence requires the irreversibility of offset or permanent storage of carbon that is absorbed from the atmosphere	A, B, C, D, F, G
Regionality	Regionality requires that the offset projects to be located within the region of emission sources	E
Co-benefits	Co-benefits refers to the ancillary benefits of the offset project to the local society	A, F, G, E, F

A: Quality Offset Initiative (2008); B: American Clean Energy and Security Act (2009); C: Tuft Carbon Initiative (Kollmuss and Bowell, 2006, p. 8); D: Carbon Tracker, E: Carbon Concierge (2008); F: Beane et al. (2008); G: Clean Air-Cool Planet (2006).

streets in public right of ways, developed public land, and trees in parks. About half of them reported that their cities own and care for trees abutting reservoirs. Likewise, 22% of all respondents reported that their cities have a complete inventory of urban trees. Another 56% indicated that they have a partial or a component inventory of public trees, whereas the remaining 23% indicated no inventories. Among the cities with tree inventories, 52% had updated their inventory within the past 2 years; another 26% had updated their inventory between 2 and 5 years ago. Inventory datasets were fairly comprehensive and contained detailed information. For example, more than two-thirds had information about species, diameter, and condition of trees. When asked about their future inventory plan, about 63% of all respondents answered that such will be conducted within the next 5 years.

Officials responsible for urban forests in cities were very familiar with the technical skills needed in carbon accounting. For example, about 75% of them indicated that the they were familiar with the U.S. Forest Service's computer program i-Tree, which is capable of analyzing tree inventory data and estimating the carbon storage in individual trees and forests. Moreover, a majority of respondents had a formal urban forest management plan. About 37% of respondents had a written management plan covering all of their publicly owned trees. Another 18% had a management plan that covering some of their public trees. The remaining 40% did not have a management plan. Some of the cities (roughly 30%) had an urban forest risk management plan, which is important in management and utilization of urban trees in case of a natural catastrophe or man-made hazard.

Fig. 1 shows the breakdown of respondents according to their priority for reducing GHGs. About 26% of respondents indicated that their government had already made reducing carbon emissions a priority. About 17% had at least discussed it. Another 20% indicated they neither had a goal of reducing carbon emissions nor had discussed it. Local governments were asked about what could motivate them to sell carbon credits. Interestingly, factors directly related to the public and environments were more likely than income to motivate them to sell carbon. For example, 67% of them indicated public relations, and 61% indicated support for environmental programs as extremely important or important factors in considering selling carbon credits (Fig. 2). Similarly, the interest from voters and support for local businesses were indicated as important or extremely important factors by 58% and 56% of respondents, respectively. Fewer (47%) indicated that the potential income from the sale of carbon credit would be an important factor in considering selling carbon credits.

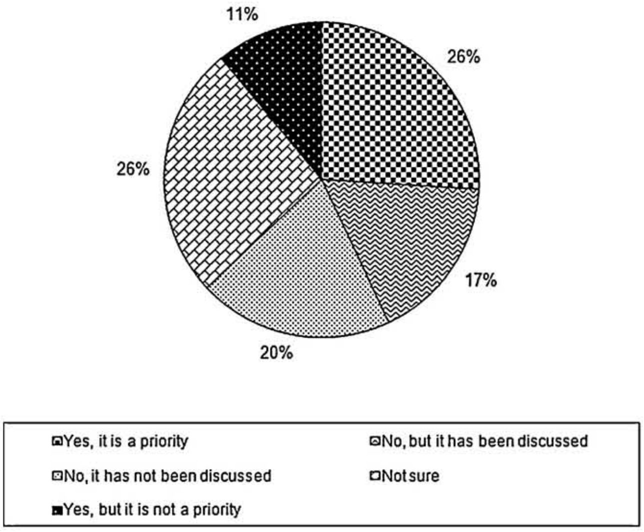

Fig. 1. Importance to local governments of reducing GHGs.

Assessing urban forest credit quality

While the survey results do not answer all the questions one may have about credit quality, responses indicate that urban carbon forest projects could meet many of the key quality criteria. In general, local governments as a supplier are committed toward reducing GHGs emissions and are more likely to sell carbon credits for envi-

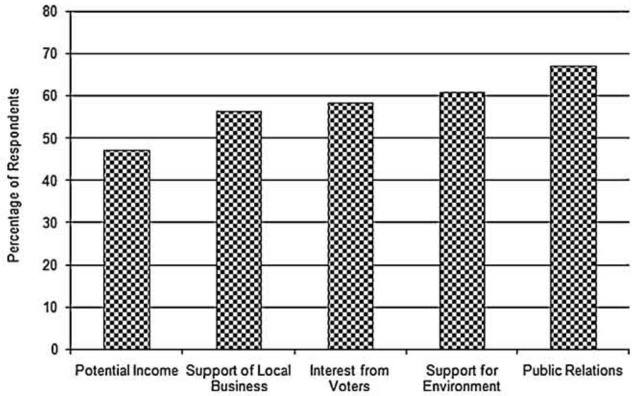

Fig. 2. Motivations for local governments to sell carbon credits.

ronmental management and public relation purposes than revenue generation, although they still may seek profits through secondary means. In case of private forest projects, forest managers usually are directly motivated by anticipated profits.

Likewise, cities appear to have technical and managerial capabilities necessary to meet at least some quality criteria. For example, the fact that a solid majority of cities have designated officials and staff units responsible for tree management could help enforce carbon sequestration projects on the ground. Many of them already have well developed forest management plans demonstrating that their trees are likely managed responsibly, or in accordance with sustainability standards, which often is required by market trading platforms. Computer-skilled officials and inventory datasets would be also useful. Some cities have pre-established plans to mitigate tree destruction from natural catastrophes, fires and diseases. These mechanisms could help better preserve sequestered carbon for longer periods. While these responses only indicate that in general urban forest credits could meet quality criteria, the following paragraphs discuss in greater detail how urban forest carbon credits would perform against each of the quality criteria identified earlier.

Additionality requires that the project demonstrates that the claimed reduction in GHGs emissions is additional to what would have happened in the absence of the project or payment for credit. Another quality criterion related to additionality is a realistically established *Baseline*, which means the proper accounting of carbon emissions before the offset project is implemented. Any reduction in the carbon emissions above the baseline is considered additional. Baseline could be established either by a base year approach or business as usual approaches (Beane et al., 2008). The business as usual approach is defined as an estimate of future GHGs emissions with no major changes in attitudes, priorities and operations of entities involved in developing carbon projects. The base year approach is used to compare the amount of emission reductions between two time periods, whereas the business as usual approach can be used to compare emission reductions over the whole period with and without the implementation of offset projects. In urban forestry, establishing either type of baseline and calculating additionality would be feasible. As the survey results indicate, a solid majority (78%) of cities in the U.S. have recent tree inventories. About 63% of them intend to conduct future inventories as well. This information could be useful in developing tree growth and carbon sequestration modeling, and comparing how much a carbon project would contribute to carbon emissions. Urban forestry units of local governments are likely to have regularly updated inventory data that could be used in cross-referencing and setting up more realistic baselines. As local governments in the U.S. are facing tighter budget constraints, investment in environmental and conservation programs may suffer. Thus, there are opportunities to establish externally funded tree planting and management schemes to sequester carbon and sell credits. Even within neighborhoods which are already urbanized, there are many fallow public lands, under-stocked marginal lands, and open spaces that have tremendous potential for forestry-based activities, including carbon sequestration (Nowak and Walton, 2005).

Another suggested criterion for offset quality is that the offsets are *Real*. This means the emission reduction from an urban forest project should represent an actual reduction and be technically valid. Questions about whether trees and forest resources that fall into the urban forestry category can technically absorb atmospheric carbon and store it in biomass and soils should be answered by the science. The best available science has demonstrated that all kinds of vegetation counted in urban forests in the U.S. are in fact capable of storing carbon. As mentioned earlier, Nowak and Crane (2002) estimated that roughly 23 million tons of carbon are annually absorbed and stored by urban trees in the conterminous U.S., giving an estimated total storage capacity of 700 million tons. These findings demonstrate that carbon credits produced by urban forestry projects have scientific validity and are real.

Quantification and monitoring is another key aspect of ensuring credit quality. It requires that projects have clearly defined components to get accurate estimates of emission reductions attributable exclusively to the given project. To satisfy this criterion, Offset Quality Initiative (2008) suggested that a monitoring plan should be developed to clearly mention the time, methods, and personnel responsible for data collection. Moreover, the measurement and monitoring plan should be developed with personnel familiar with the credit project, quantitative techniques, and other required protocols. Our survey indicates that a vast majority of cities and municipalities do have professional urban foresters or arborists, who are likely to be familiar with tree measurement techniques and have some understanding of forest carbon sequestration. The survey also indicates that most of them are familiar with the advanced computer inventory programs (e.g., i-Tree). Periodic inventory data can be analyzed in this program to generate updated estimates of carbon absorption rates and volume storage in urban trees.

Another quality criterion requires that the credit be independently *Verifiable*. Satisfying this criterion should be routine for urban forests. The verification is carried out by a third party based on a number of established protocols. Contracting out this can be a barrier and burdensome to some project managers. For example, documentation of verification process, and the associated cost can make the credit production expensive, potentially leading to very minimum or no profit margin in the current voluntary market with very low credit price. However, such difficulties and challenges in meeting this criterion should be similar for all types of credit projects and may no longer be an issue with a mandatory regulation in place in the future. Nonetheless, compared to other offset projects run by private individuals, the human resources and technical capacities of urban forestry management units would certainly make this process more efficient, transparent, and straightforward.

Unambiguous ownership of the credit is another key criterion. Similar to the idea of exclusivity with other market goods, this means that the title to the credit should be unique and cannot be sold to multiple buyers at the same time nor can it be counted as the credit by multiple parties. Ownership-related issues in urban forest carbon projects could be analyzed from various perspectives. First, the ownership of the project itself (i.e., trees that sequester atmospheric carbon) is not jointly owned and cannot be subject to disputes such as joint venture properties in the private sector. As our survey indicates, trees along public right of ways, parks, reservoirs and other public lands constitute urban forests in the U.S. Land where the trees are grown is unambiguously owned by the corresponding city or local governments, which are also entitled to credits they produce. Because of this, it is not possible for multiple parties to claim ownership. One caveat which needs to be addressed is that sometimes cities defer management of right-of-way trees to the adjacent landowner. If such project ambiguity arises, it needs to be clarified with respect to permanence and leakage. Further, the management of trees in different properties owned by a city could be different and may need different set of protocols to measure and verify the additional carbon stored after project implementation. Another possible ambiguity in ownership is the actual title of credits once entered into the market. Like other credits, once a city or municipal government registers its carbon credits in a registry, it is assigned with a unique ownership identifier and the possibility of double counting of credits is avoided.

Addressing *Leakage* is also required for high quality credits. Leakage could be a serious issue in forest projects as given the reliance on forests to supply various products, including timber. Beane et al. (2008) argued that there are two types of leakage possible. First is the internal leakage, which occurs when the implementation of a credit project causes an increase in emissions within the project owner's ownership. For example, a private landowner with his properties in multiple locations in the southeastern U.S. may preserve forests on some parcels to offset GHGs emissions and sell credits, while increasing timber harvesting on other parcels. The second is external leakage, which occurs when emissions shifts outside the project owner's ownership. For example, when there is high market demand for timber and many of non-industrial private forest landowners in the area delay harvesting to store carbon, timber harvesting will increase on industrial timberland, resulting in a net loss of sequestered carbon. In case of urban forest offset project, both kinds of leakage are not an issue because urban trees are typically not subject to market forces. In other words, urban forest trees are not grown to supply conventional forest products. No urban forests covered by our survey were reported as grown for commodity production. Tree planting, conservation, and management on public lands are likely to put minimal or no pressure on other forest products sectors because urban forests in the U.S. currently does not substitute for family or industrial forests, as far as forest products are concerned. Therefore, it is reasonable to assume that any credit sourced from urban forests is leakage free. However, a potential leakage in urban forestry could be from activity shifting. For example, if cities or municipalities as managers of these projects stood to profit by focusing resources on new planting and neglecting existing urban forestry stocks, that will eventually create leakage. Additional verification criteria and indicators will be required to prevent such leakage in urban forestry projects.

Another quality criterion is *Permanence*, which requires strict credit irreversibility. In other words, carbon removed from the atmosphere should not re-enter the atmosphere. Showing permanence in forest projects is more challenging than any other kinds of projects because trees are harvested and carbon stored in them will eventually be released. This type of reversal is also possible in forestry projects because of the catastrophic shocks such as fire or diseases. However, there are several reasons to believe that urban forests would perform well in this respect. First, urban forests and trees are not grown for harvesting and wood products manufacturing. Second, since urban trees are usually managed for ornamental, amenity and aesthetic values, they are likely to be retained for longer periods if not in perpetuity. As residents in the urban areas grow with the trees in their neighborhoods, streets and squares, people place value on them for their cultural significance, emotional attachment, and place characteristics (Dwyer et al., 1992). Such public support helps keep the trees around for a long time and preserves the carbon stored in them. Third, about 30% of the cities and municipal governments we surveyed had risk management plans for their trees and forests. In order to avoid increasing human casualties and high clean up cost following tree damage as a result of bad weather, many local governments in the U.S. are currently developing risk management plans. Such plans help mitigate or prevent mass mortality of urban trees due to fires, disease outbreaks or other natural catastrophes. These preventive measures will eventually help in avoiding the loss of tree carbon and maintain permanence. However, there is no general consensus as to how long (project period vs. perpetuity) the permanence criterion should hold (Beane et al., 2008).

It should be noted that there is no evidence to suggest that the carbon sequestered by urban trees stays longer than that stored in other types of projects. However, unlike other types of offset projects, urban forestry project is defined in terms of trees sites rather than actual trees, and owners of such projects are likely to maintain such sites forested for a very long time, which could have potentially become a parking space, sidewalk or building. Given the nature of project ownership, the urban forestry projects defined in terms of tree sites and operated by public institutions are less likely than private forestry projects to be influenced by market forces, and undergo conversion, thereby sequestering the carbon for a longer period. Alternative projects such as forests in private ownership are more likely to be influenced by real estate market prices and be converted to developed uses, or forests in multiple use management objectives can experience higher harvesting frequency, and projects with no risk management plan in place can have lower ability to save trees from disease, pests, or natural catastrophes. Therefore, ownership characteristics, management objectives, and the ability of local governments to manage risks as demonstrated in survey indicate the urban forestry's potential to establish permanence.

Two additional criteria including *Regionality* and *Co-benefits* are often mentioned to highlight the quality of carbon credit even though there is no scientific justification to link them with the actual quality of the sequestration method. *Regionality* places higher value on offset projects located in the same region as emission sources (Carbon Concierge, 2008). The region that generates a lot of emissions has moral and ethical responsibility to take leadership in offsetting its emissions; this criterion becomes important in assessing credit quality. Urban forest credits are more likely to meet the regionality criterion because most of industries and transportation facilities are located in cities and metropolitan areas. As the urban trees are also within the region of significance, they certainly meet this criterion. Another attribute of urban forestry associated with the regionality criterion is that local companies that buy credits sourced from local urban forest projects can more easily verify whether the projects they are paying for exist and are actually working on the ground. This benefit obviously would be less available to companies located in North American urban areas, which buy credits from projects in rural America or internationally.

The *Co-benefits* criterion is concerned with the types of ancillary benefits offset projects being to the society. While all kinds of forestry or green projects may meet this criterion, urban forest credits would be a perfect project. Trees in urban areas help maintain greenery, mitigate air and noise pollution and provide habitat for birds and other species (Dwyer et al., 1992). Urban forests provide open space and recreation opportunities to urban residents. Trees near residential building and business facilities provide shade and conserve energy (Simpson and McPherson, 1996) which would, to some extent, help avoid emissions of GHGs (McPherson, 2007). For example, a case study measuring such benefits found that about ten thousand urban trees in the city of Golden, Colorado saved about $23 per household in energy, avoided more than $50,000 costs in storm water management, and removed 9 metric tons of net ozone air pollution (Lyons, 2009). Further, as home buyers in cities pay a price premium for houses with surrounding trees, it could help to enhance local tax revenues which can subsequently be invested in poor or underserved communities.

Conclusion

Based on the nationwide survey of local governments, we extended the discussion of whether and how carbon credits from urban forest projects fulfill certain quality criteria. The information collected from local governments about their current capacities and resources and an analytical discussion about the quality of urban forest credit attributes provide strong evidence and reason to believe that many municipalities have the capacity to implement urban forest projects that meet quality criteria currently espoused in the literature.

The findings presented here have several implications for urban forest management and carbon credit marketing. First, while urban forest credits could meet all of the key quality standards, they perform better in some quality aspects than other types of credits. For example, permanence, regionality, and co-benefits are the three key quality criteria in which urban forest credit sellers have an advantage. Because of their contributions to the quality of environment, aesthetics, and public health, urban forest credits do no net harm. Second, due to an increasing number of credit sellers entering carbon markets, these markets are becoming increasingly competitive. A recent report by the U.S. Government General Accounting Office warned that the quality assurance of carbon credits would be a challenge for credit sellers (GAO, 2008). It will be crucial for all potential credit sellers to demonstrate that their credits are real and of high quality. As this study is the first to clearly demonstrate how urban forest credits meet quality criteria, it provides guidelines to local governments for promoting their credits.

Likewise, as recent surveys indicate that the buyers do not have enough information about the quality of offsets available in the market, key observations presented in this paper will offer guidelines for companies interested in buying quality credits. Other non-profit organizations interested in environmental conservation also might find this information useful to develop an agenda for promoting private investment and alternative funding for urban forestry. If local governments can sell quality credits that consumers are increasingly demanding right now, private companies that are currently selling low quality credits will be forced to either cease their operations or enhance their credit quality, eventually leading to an overall improvement in quality of carbon markets and consumer welfare.

Third, urban forest mangers as credit sellers may have an additional advantage by being more competitive than other credit providers in the market. For example, as our survey demonstrates, they have technical and human resources required to estimate carbon storage and they can enter the market with possibly lower start-up costs, depending on project characteristics. Also, recent studies have projected that the urban share of land in the U.S. could increase from about 3% in 2000 to more than 8% in 2050 (Nowak and Walton, 2005). This provides an opportunity for establishment of a substantial number of urban forestry projects and for generating carbon credits, which could be directly sold to buyers at carbon trading platforms. By doing this, they do not need to pay aggregators for aggregation or marketing fees out of their revenue and offer quality credits at a competitive price. Nevertheless, the future supply of quality credits from urban forestry will largely depend on whether and how these cities translate their potential into action. Having a management plan or being familiar with some carbon measuring tools and market outlets is different from understanding them and being able to use strategically. A caveat of our study is that the respondents were not asked about how they have used those resources and information to implement the project, partly because the urban forest carbon projects are relatively new and it will take a while to see how cities can use their capacity to implement. However, having access to information, resources and potential capacity would make market entry cheaper and easier. Thousands of cities nationwide would benefit from extension programs aimed at enhancing their capacity to use those tools and to be proactive in carbon marketing. As some of the commercial carbon trading platforms like CCX have just started approving urban forestry projects for registration, future research could focus on thorough evaluation of such projects to examine how cities or managers of such projects can translate the potential into actions and outcomes.

In addition to positive attributes, urban forest credits may have a few weaknesses as well. For example, the issue of 'scalability' i.e., the scope of geographical expansion of credit projects might be more limited for urban forestry than for other projects. However, as cities will expand along rural landscapes, and as demand for open space rises in already developed areas, there will be more public land available to forestry. Future studies could focus on surveying credit buyers asking if they are willing to pay a price premium for urban forest carbon credit for the attributes that make it unique, high quality, and more desirable than other credit types.

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