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Analysis

Transactions costs of expanding nutrient trading to agricultural working lands: A Virginia case study

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ABSTRACT

Agricultural nonpoint sources (NPS) figure prominently in the design of many water quality trading programs. In concept water quality trading programs can create incentives for agricultural operators to supply low cost pollutant reductions while still keeping land in agricultural production. In practice water quality trading programs in the United States have produced few trades involving agricultural NPS. Transactions costs are a critical, but poorly understood, feature of water quality trading programs. The objective of this study is to examine the transactions costs associated with expanding the use of NPS credits in a water quality trading program in Virginia (United States) to include credits generated from agricultural working lands best management practices (BMPs). Findings indicate that transactions costs for agricultural NPS trades in Virginia are currently relatively low, due to the activity being credited: simple land conversion. Based on best available evidence, transactions costs of creating credits using management and structural BMPs will be 2 to 16 times more costly on a per project basis than for land conversion credits. Compliance monitoring protocols are a significant driver of costs for working lands credits. Our results suggest an important cost/risk tradeoff between verification costs and compliance certainty for program designers to consider.

1. Introduction

Many trading program administrators, economists and policy makers encourage the involvement of nonpoint source (NPS) agriculture in water quality trading (WQT) programs (Jones et al., 2010; Ribaudo and Gottleib, 2011). In WQT programs, regulators grant regulated parties (point sources) off-site effluent control options for complying with legally enforceable effluent control requirements. Some researchers and regulators advocate expanding trading options to include agricultural sources on the grounds that these sources can achieve effluent reductions at lower cost than regulated point sources, thus potentially lowering the overall compliance costs (Van Houtven et al., 2012).

However, crediting of nutrient reductions generated by agricultural NPS best management practices (BMPs) for use in regulatory compliance programs introduces additional administrative and coordination costs beyond effluent abatement costs. First, agricultural NPS crediting programs are likely to involve a relatively large number of small, decentralized actors (Abdallah et al., 2007). Co-ordination costs will be incurred to locate and contract landowners, and to aggregate credits for sale. Second, many agricultural BMPs used on active farmland (BMPs on 'working lands') involve complex activities being implemented in dynamic farm settings, making credit-generating projects potentially costly to contract, certify, and monitor. Third, assuming WQT is operating in a regulatory context, costs are incurred to demonstrate and verify relationships between practice implementation and water quality outcome (such as modelling and/or monitoring water quality gains associated with particular practices). Finally, many agricultural BMPs generate effluent reduction services for a limited duration, which means that regulated parties may need to contract nonpoint source credits over multiple sources and terms to cover obligations to meet current and future regulatory permit conditions.

Empirical research on transactions costs for WQT programs that include NPS agriculture is still an emerging field of inquiry. Despite widespread interest in point-nonpoint trading, large scale trading between regulated sources and agricultural operations remains rare. NPS credit trading has been largely confined to 'pilot programs' that operate on a small scale or limited timeframe, or used for non-regulatory

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purposes to demonstrate proof of concept. Understanding transactions costs in WQT programs is important because transactions costs may reduce the supply of nonpoint source credits, increase total compliance costs, and decrease the relative cost-effectiveness of agricultural reductions (Stavins, 1995). Also, improved knowledge of transactions costs assists agencies to better understand the upfront and continuing costs of WQT programs that include NPS agriculture and provides insight on how programs may be designed to be more cost-effective.

The objective of this study is to examine the transactions costs associated with specific aspects of agricultural NPS participation in WQT programs. We use a case study approach that examines the possible cost consequences of expanding the use of NPS credits to agricultural working lands BMPs in Virginia. Virginia has enacted several nutrient trading programs for regulated sources discharging into the Chesapeake Bay. The Chesapeake Bay currently does not meet ambient water quality standards due to excessive anthropocentric loads of nitrogen and phosphorus. While most agricultural sources remain unregulated, some observers expect nutrient trading will provide additional incentives for agricultural nonpoint sources to reduce nutrient loads (Jones et al., 2010; USDA, 2010). To date, agricultural NPS involvement in Virginia WQT programs has been minimal, with credits being produced and sold only for land being taken out of agricultural production ('land conversion'). We discuss transactions costs for the current program, and draw on experiences from other existing WQT programs and related conservation programs to construct plausible estimates of likely administrative transactions costs that could be incurred if the Virginia program expands to include agricultural NPS credits generated on working lands. We focus particularly on two components of transaction costs: ex ante costs of contracting for credit-generating conservation projects (costs incurred prior to the sale of credits), and ex post costs of monitoring regimes (costs incurred after the sale of credits). We find that transactions costs in these components depend on the type of project(s) implemented, and on program decision variables such as type and frequency of monitoring actions.

The analysis excludes some elements of administrative costs (e.g. fixed program costs and buyer search costs) and may not reflect costs as experienced by program participants, as transactions cost incidence varies with program design. Also, the analysis does not take into account transactions costs associated with meeting 'baseline'[2] requirements, which may be substantial. Nevertheless, we provide an illustrative relative comparison that offers insight into the relative magnitude of transactions costs changes that might occur if credits were generated from working lands BMPs rather than land conversion.

2. Transactions Costs of Nutrient Trading Programs

2.1. Conceptual Framework

Definitions and conceptual classifications of the components of transaction costs can be found in the literature (McCann and Easter, 2000; McCann et al., 2005; Krutilla and Krause, 2010). Drawing from this literature, we adopt a broad definition of transactions costs to include both the cost of developing trading program rules and the costs involved in program and trade implementation (Marshall, 2013; McCann and Easter, 2000; Claassen et al., 2008; McCann et al., 2005). Drawing from this literature, Rees and Stephenson (2014) developed a comprehensive conceptual framework for assessing transactions costs in WQT programs (Fig. 1). The framework classifies transactions costs into three stages: (1) the 'legislative environment' stage, in which necessary underlying rule structures, such as supporting or enabling legislation, are formulated; (2) the 'regulatory design' stage in which program rules are formulated; and (3) the 'implementation' stage, in which the program is operational. The current study restricts attention to *implementation* (stage 3).

The implementation stage comprises what are typically considered "market transactions costs" (McCann et al., 2005), but is extended to allow for characteristics specific to water quality trading (and other similar environmental markets). Unlike markets for conventional goods and services, water quality markets involve the exchange of a "regulatory commodity"[3] (Dudek and Wiener, 1996), the existence of which occurs entirely within the operation of the trading program. This leads to several types of transactions costs in the 'implementation stage' that may be additional to the notion of "market transactions costs" of trading other types of goods (e.g. agricultural commodities). We divide these into transactions costs that are incurred in the process of creating the marketable (regulatory) commodity (Fig. 1, 'Credit Creation'), and transactions costs incurred to verify the continued existence of the commodity (Fig. 1, 'Monitoring and Enforcement'). These two transactions costs categories are of principal interest in the current study.

Transactions costs generating activities that fall under 'credit creation' include participant search costs (which may include costs related to targeting and/or verifying participation eligibility), contracting for the activities which are to provide promised effluent reductions, provision of technical assistance, certification that practices have been installed as per rule requirements and registering credits. Also, if programs make use of numeric or practice-based baselines, transactions costs will be incurred to demonstrate baseline compliance.

After the credit has been created, it can be sold in the market. Market transactions costs incurred here are generally the same as those incurred for non-regulatory commodities (trading partner search, negotiation, trade approvals, registry costs, price reporting, etc.). However, unlike conventional markets, WQT programs may include requirements to demonstrate trading eligibility. For example, before being eligible to purchase NPS credits, point source buyers may need to demonstrate that they have exhausted onsite opportunities to reduce pollution (Shabman et al., 2002).

In the 'monitoring and enforcement' element of implementation, transactions costs are incurred because of the program administrator's need to ascertain whether the 'link' between the tradeable credit and the underlying environmental service provision is being maintained, and to undertake enforcement actions if it finds that the link is broken. In other words, costs continue to be incurred after sale of the credit to verify the continued existence of the commodity. The timing and level of these ex-post transactions costs will be driven by the types of activities that generate credits (e.g. structural vs management BMPs or land conversion) and level of certainty that is required. Finally, if the administrator elects to outsource certain certification or monitoring functions to third parties, transactions costs may be incurred to train, accredit, and monitor these entities.

Which parties bear the transaction cost depends on specific design features of each program (Coggan et al., 2010). For example, in one possible program configuration, landowners themselves contract directly with the program administrator or buyer to produce credits, whereas in another a 'credit provider' contracts with the landowner to provide access to the land, and the credit provider installs and maintains the BMP and interacts with the credit certifying agency. Examples of other program design features that will affect transaction cost incidence are whether the program administrator pays monitoring costs or recovers those costs from the buyer or seller.

[2] 'Baseline' refers to "the pollutant control requirements that apply to a buyer and seller in the absence of trading …. A baseline for a nonpoint source can be derived from a load allocation (LA) established under a total maximum daily load (TMDL)" (USEPA, 2007, p. 6).

[3] There are various types of tradeable water quality credits, distinguished by pollutant type (nitrogen, phosphorus or temperature), and duration (e.g. permanent, fixed-term). Also, some programs distinguish between 'credits' (which refers to abatement in excess of current regulatory requirements or non-regulatory baseline), 'offsets' (abatement to 'offset' expansion in effluent discharge associated with new facilities and/or growth), and 'allowance' (authorization to discharge a specified level of effluent load). We use the term 'credit' generically in this study.

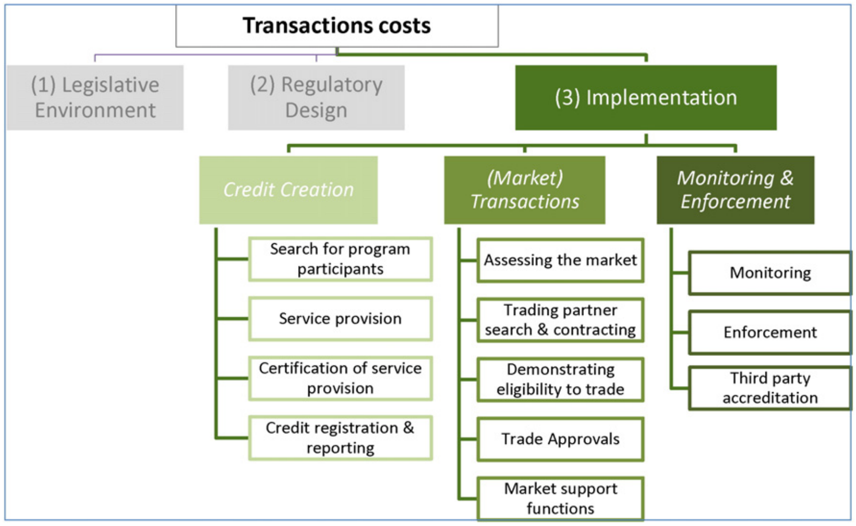

Fig. 1. Transactions costs conceptual framework.
Source: adapted from the literature, see Rees and Stephenson (2014).

2.2. Existing Evidence on Transactions Costs in Water Quality Markets

A number of studies examine the transactions costs of various conservation service provision programs (e.g. Claassen et al., 2008; Coggan et al. 2013; Falconer and Saunders, 2002; Groth, 2008; Mann, 2005; McCann and Easter, 1999, 2000; OECD, 2005a, 2005b, 2005c). Estimates of transactions costs from these studies, as a percentage of program costs, vary substantially. For example, Claassen et al. (2008) report that administrative transactions costs in the US Conservation Reserve Program are only 1% of total program costs, while Falconer and Saunders (2002) report transactions costs as constituting up to 112% of compensation costs paid to eligible land holders under certain types of conservation management contracts. While estimates are difficult to compare across studies due to differences in definitions and methodologies, these studies show that transactions costs can be substantial, and identify various factors which affect transactions costs.

Despite the increased attention being devoted to studying transactions costs in conservation programs in recent years, to date there are very few studies available that attempt to quantify transactions costs of water quality trading programs specifically. Fang et al. (2005) present transactions costs estimates for the Rahr Malting Company trading program in the Minnesota River Basin that allowed Rahr Malting Co. to offset projected loads of CBOD5 (five-day carbonaceous biochemical oxygen demand) from a new wastewater treatment plant by purchasing credits from agricultural NPS. The authors estimated program costs without and with transactions costs, and found a 35% increase over the five year project period when transactions costs were included. The majority of transactions costs were incurred in the initial permitting phase for the point-source buyer (which comprised elements of both *regulatory design* (stage 2) and *implementation* (stage 3) in our conceptual framework), as the regulatory authorities had to simultaneously establish the underlying technical basis of the trade as well as implement the trade for a single permittee.

Newburn and Woodward (2012) assessed the Great Miami Trading Program (GMTP) in Ohio, a pilot WQT program administered by the Miami Conservancy District (MCD). Credit-generating projects are monitored by Soil and Water Conservation Districts (SWCD) agents who report to MCD. Estimated transactions costs constitute payments made from MCD to the SWCD for initial staff assistance to the farmer and SWCD monitoring costs; however, the authors note that there was substantial under-recovery of SWCD costs from MCD. MCD costs of recording of credits, administering a credit auction, program oversight/coordination, and remediation costs for noncompliant actors were not reported, nor were buyer or seller-related costs. Consequently, the transactions costs reported likely underestimate the true total costs of administering the trading program. These caveats notwithstanding, Newburn and Woodward (2012) report that total transactions costs of SWCD initial assistance plus monitoring are on average 5% of total program costs, with reported variation in this figure across counties from 0% to 12%.

These case studies, however, offer limited insights into the broader discussion of transaction costs in WQT. The Rahr program was designed to create water quality credits from a limited range of practices (farmland conversion to native floodplain and streambank erosion controls) to be used for compliance with NPDES permits for a single permittee, while the GMWTP is still a *voluntary* program. Many studies on transactions costs for conservation programs in general assume costs will tend to fall with increasing program maturity, as learning occurs for both administrator and scheme participants, scale economies emerge (e.g. more credits or contracts are spread over fixed administrative costs) and application and approval processes become more streamlined. Indeed, several studies show this result overall for a variety of existing conservation programs (see for example Challen, 2000; Falconer and Whitby, 2000; Falconer et al., 2001; Garrick et al., 2013; Groth, 2008). However, an evaluation by Antinori and Sathaye (2007) of 'nascent' versus 'mature' emissions trading markets suggests a more complex picture. While their results for overall transactions costs supports the notion that transactions costs fall over time, they find that costs for some components increase as the markets mature or as programs expand. In particular, insurance costs and regulatory costs increased substantially as compliance standards became stricter or more rigid when programs moved from a "pilot phase" to being used to generate credits for regulatory compliance.

Regarding credit creation and credit monitoring, transactions costs might be expected to increase both by the number of practices covered by the program, and the complexity of the practices in the program. The Rahr program covered only two practice types - farmland conversion to native floodplain and streambank erosion controls. Both practices generate credits over relatively long useful lives and do not actively involve agricultural practices on working farmland. Antinori and Sathaye (2007) find that expanding the scope of programs to allow more types of credit-generating projects will increase complexity and may prevent standardization of processes which could otherwise serve to streamline transactions costs. Furthermore, the duration of the credit-generating activity (annual management practices versus long term structural practices) would also be expected to directly impact the credit certification and monitoring costs. Since credit creation and ex-post monitoring are both logically sensitive to the number, type, and frequency of credit practices, we focus on considering transactions costs in these areas and omit transactions costs of market exchange.

3. Nutrient Trading in Virginia

Virginia has developed several related nutrient trading programs to serve the regulatory compliance needs of regulated source sectors, including regulated municipal and industrial wastewater point sources and land developers (§ 62.1-44.19:12 through 19). New and expanding point sources must offset all new loads but have yet to utilize agricultural NPS credits. Supported by a capital grants program, wastewater point sources have produced substantial over-compliance and excess point source credits, dampening demand for NPS credits (Stephenson et al., 2010). Virginia Department of Environmental Quality (VDEQ) is authorized to expand trading options to other sectors including the municipal stormwater permittees (MS4s) and urban land development permittees.

Virginia legislation broadly defines how certified nutrient reduction credits can be created (§10.1-603.15). Nutrient credits may be created by regulated point sources, agricultural BMPs, land retirement, manure conversion technologies, wetland and stream restoration, and enhancement of nutrient sink functions (e.g. algal and shellfish harvest). Virginia published guidelines for calculating credits from agricultural nonpoint sources (VDEQ, 2008). Virginia DEQ quantifies nutrient credits for a select number of BMPs, but rules allow for credit providers to use any BMP where performance has been documented through research. Installed credit-generating BMPs should meet published (VDEQ, NRCS) design standards. Virginia also does not specify parties responsible for credit creation and marketing (farmers, landowners, brokers/aggregators, conservation organizations etc.), but legislation seems to anticipate the role will be fulfilled by third party "brokers" (§ 62.1-44.19:12 through 19).

NPS credit demand to date has come exclusively from the development community via construction activities under the Virginia Stormwater Management Program (VSMP). In Virginia, developers with land disturbance of a certain size must meet numeric post-development water quality criteria, defined as a per acre phosphorus load (see Virginia Regulation 9VAC25-870-63). The VSMP allows developers opportunities to meet some or all (depending on project size) of these phosphorus control requirements offsite through the purchase of "perpetual" phosphorus credits (one pound (0.45 kg) of P reduction in perpetuity). Given that Virginia requires perpetual credit offsets for long-term land development impacts, land conversion (e.g. conversion of agricultural working lands to less nutrient intensive uses like forest and protected in perpetuity) has emerged as the key nonpoint source offsetting activity. To date, VDEQ has approved 28 agricultural NPS credit projects provided by 17 credit providers, generating 2379 permanent phosphorus credits and selling 893 credits (VDEQ registry as of 04/07/2016; VDEQ). All projects except one are land conversion projects (the other was a regional stormwater pond).

Fig. 2 shows the general process and entities involved in the Virginia credit trading option under the VSMP construction program. Attention is focused on the credit-generating side of program implementation, and although it includes market transactions with the developer and local stormwater program, it is simplified for purpose of exposition.

In the VSMP phosphorus trading program credit providers are typically third parties that contract with landowners to implement the credit-generating BMP (see Fig. 2). These credit providers, rather than the landowner, incur the search and administrative costs necessary to certify credits through VDEQ. Credit providers market the credits to regulated parties. The landowner can be thought of as an 'input supplier' who is contracted by the credit provider. Landowners receive payment from the credit provider for restrictions on land use either as a direct payment or as a share of credit sale revenue. Virginia rules do not prevent landowners from creating and selling credits directly, but credit providers provide specialized knowledge and skills to reduce the transaction costs of certifying and marketing environmental service credits (many phosphorus credit providers are also wetland/stream mitigation bankers). Wetland and stream mitigation banking employ similar contracting structures.

The necessary steps for the credit provider are: (1) contracting with the landowner regarding access to and preservation of the credit-generating site; (2) tree planting (i.e. conversion to forest); and (3) certification to ensure that the project meets land conversion performance requirements (pers. comm. Aaron Revere, Falling Springs LLC, 2014). Under proposed credit certification regulations, credit providers pay fees to partially compensate VDEQ for the transactions costs incurred in the certification process (Virginia Regulation 9VAC25-900-210 and 220). VDEQ is responsible for program administration. Key implementation activities for VDEQ are processing applications for credit creation from credit

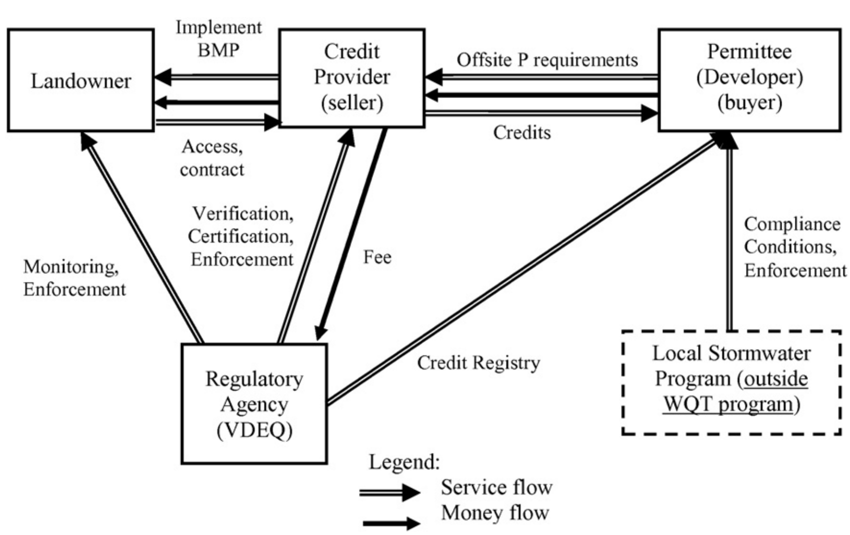

Fig. 2. Credit generation and transfer process: Virginia (permanent) phosphorus credits.
Source: adapted from Rees and Stephenson (2014).

providers, registering new credits (and maintaining the registry), certification and ex-post monitoring of credit-generating practices, and enforcement.

Quantitative transactions costs data relating to current 'market transactions' was not available for Virginia, and in general is difficult to obtain. However, qualitative evidence suggests that trading partner search and contracting in the Virginia WQT program are relatively simple tasks undertaken only once. One credit provider interviewed commented that cost and time to move projects through the process is straightforward and the costs are low compared to those incurred in other environmental service markets (pers. comm. Aaron Revere, Falling Springs LLC, 2014).

VDEQ provided data for staff time spent in site visits for BMP verification and credit certification for five agricultural land conversion projects which have generated credits. On average 2 visits occurred for each project, and total staff hours spent on site visits ranged from 6 h to 17 h (average 10.6 h). Note that these estimates relate to site visits only and do not account for accompanying time spent reviewing project plans, processing paperwork relating to the site visit, unplanned trips, credit registry management, or compliance monitoring. VDEQ does not consider that these costs and activities are currently problematic or large.

VDEQ employs remote sensing to monitor the land conversion projects which have so far generated permanent credits (pers. comm. Allan Brockenbrough, VDEQ). VDEQ reported that it takes only around a quarter of an hour to remotely verify the status of a land conversion to forest project. This low cost arises because VDEQ's monitoring regime does not involve site visits, and because monitoring consists of simply ascertaining the number of stems evident per acre.

4. Transactions Costs of an Expanded Virginia Program: Credit Creation and Monitoring

Transactions costs of credit creation and ex-post monitoring are likely to increase if nutrient trading is expanded to NPS credit generation from working agricultural lands. Operating within Virginia's existing nutrient trading programs, expanding nutrient credits to working lands could potentially add transaction costs due the increased complexity of the best management practices and the frequency with which the credit providers and regulatory agency must create, certify and monitor credits. However, very limited empirical evidence or experience exists to indicate how transaction costs might change due an expansion of credit-generating activities to working agricultural lands. To date, few trades involving working land BMPs have occurred within the context of regulatory nutrient trading programs (programs where the buyer is purchasing credits for permit compliance). In cases where trading has occurred, very limited direct empirical data on administrative transaction costs is collected or recorded.

To estimate how costs might change in such a limited information environment, we construct transaction cost estimates based on the assembling the best available relevant secondary evidence. We draw upon evidence from trading programs where available, and also draw on the experience and records of the conservation agencies/organizations which has extensive experience in contracting for the kinds of agricultural BMPs that would generate fixed term credits. Information concerning the current transactions costs of this program was gathered via detailed telephone interviews with key program participants, with follow up via email and telephone where necessary. This approach relies on the evidence provided by specific expert individuals, and is similar to that taken by McCann and Easter (1999) and Thompson (1999). This approach has the drawback of being 'piecemeal', and necessarily assumes cost estimates and insights from other programs are relevant to the consideration of an expanded Virginia program. Reconciling and corroborating evidence from a variety of sources, however, can provide confidence in assembled evidence. While further research is warranted, the insight drawn from this exercise provides a useful indication of the relative differences in the transactions costs of different types of credits, and allows us to identify factors which are likely to be drivers of these costs.

4.1. Transactions Costs of Creating Term Credits

Creating credits from working land BMPs will potentially differ from simple land conversion projects in a number of ways. Credit providers must work with farmers/landowners to identify and credit nutrient reductions from non-permanent projects. Some of the practices might involve relatively complex management or engineering designs to implement. Agencies must then certify implementation.

While little data exists from water quality trading programs, public conservation agencies have extensive experience working with landowners/farmers to select and implement conservation practices. Estimates of the cost to create agricultural NPS term credits were based on estimates of staff time incurred by the Natural Resource Conservation Service (NRCS) to contract for the installation of conservation practices, called "best management practices" (BMPs). NRCS processes for conservation planning under federal financial assistance programs are similar to those activities needed to generate nutrient credits. Moreover, some WQT programs use state/federal conservation staff for this task within their programs (Newburn and Woodward, 2012).

The NRCS conservation planning experience provides a common basis for estimating 'credit creation' transactions costs of both permanent and term credits that is currently not available from existing WQT programs. We gathered initial staff time requirements via detailed personal interviews with NRCS field office Area II (in southwestern Virginia). The staff interview process consisted of extensive multi-day interviews at the field office concerning steps and time required to implement conservation on the ground. The staff provided a sample site visit and copies of forms and procedures needed to complete a conservation contract. Data was also obtained on the rate at which landowners/farmers dropped out during the conservation planning process (attrition rates).

Estimates of staff hour requirements and attrition rates were verified with state-level administrative staff in Richmond. Estimates of staff hours, costs, and/or attrition rates were also corroborated by staff from the Ohio River Basin Trading Project (ORBTP), a pilot program administered by the Electrical Power Research Institute (EPRI) (pers. comm. Jessica Fox, EPRI, 2014), although EPRI did not provide its own quantitative estimates. Furthermore, NRCS field office information on staff requirements for conservation planning was corroborated with the experience of private conservation consultant NGO in Virginia and generally found to be consistent.

NRCS field staff use the 'NRCS Virginia Contracting Checklist' for every successfully completed contract. This 'checklist' constitutes a detailed list of activities that must be performed for each contract. NRCS staff provided estimates (measured in hours of agency staff time) for each activity on the checklist, which have been here aggregated into 6 'stages' in the NRCS planning process: *inception* (initial meeting and site visit), *planning and application*, *approvals*, *contracting*, *implementation* (pre-construction meeting/site visit, engineering designs developed, technical assistance provision, follow-up and spot checking of contracted item(s)) and *check-out*[4] (verifying correct installation of practices). These steps are generally consistent with the type of activities currently performed by private credit providers and state agency staff in the nutrient credit certification process.

NRCS staff noted that time commitments vary substantially between contracts depending on the type and complexity of the practice(s) being

[4] We use the term 'check-out' here to distinguish NRCS certification of BMP installation from 'certification' and 'credit registration and reporting' in a WQT program, which require both verifying correct BMP installation and certifying creation, registration, and release of credits.

Table 1
Estimates of NRCS field staff hours required to complete conservation contracts[a].
Source: pers. comm. Hunter Musser, NRCS District Conservationist (Virginia, Area II).

Task	Simple contract			Moderate contract			Complex contract		
	Low	High	Avg[d]	Low	High	Avg[d]	Low	High	Avg[d]
Inception	1.5	2.0	1.8	1.5	2.0	1.8	1.5	2.0	1.8
Planning & application	5.5	7.9	6.7	7.8	11.5	9.7	12.8	17.8	15.3
Approval	3.7	5.3	4.5	3.9	5.5	4.7	4.4	7.0	5.7
Contracting	5.2	6.8	6.0	8.3	11.9	10.1	13	17.6	15.3
Implementation	3.0	3.5	3.3	14.0	18.0	16.0	25.0	32.0	28.5
Check-out[b]	1.3	1.7	1.4	2.0	3.0	2.5	9.0	25.0	16.0
Total hours[c]	**20.1**	**27.1**	**23.6**	**37.5**	**51.9**	**44.7**	**65.8**	**101.3**	**82.5**

[a] Estimates are for *first-time participants*: the District Conservationist noted that there are often efficiencies for repeat contracts, typically because participant is familiar with the program and NRCS staff are familiar with the conservation concerns of the site.
[b] Check-out hours are dependent on the average number of items in the contract, as follows: Simple (low): 1, Simple (high): 2, Moderate (low) 2, Moderate (high) 4, Complex (low): 4, Complex (high): 8.
[c] Estimates include travel time for site visits, assumed as follows: 1 h average travel time round trip per site visit, visits occur in following stages: *inception*: 1 visit (all contract types); *planning & application*: 1 visit (all types); *implementation:* (simple/moderate contract: 2 visits, complex contract: 3 visits), *check-out*: 1 visit (all types). Totals may not add due to rounding.
[d] Average = simple mean of *low* and *high* estimates.

installed. Time estimates (Table 1) were provided for each step of the planning and contracting process for 3 representative contract types:

1. *Simple contract: type (a)* single BMP that does not require engineering plans or complex management plans (e.g. cover crop or livestock exclusion fencing); *type (b)* land conversion to pasture or forest.
2. *Moderate contract*: Livestock exclusion fencing plus provision of alternative watering facilities. May include an invasive species control plan.
3. *Complex contract*: Animal waste management facilities on an intensive dairy farm: requires several engineering practices, such as heavy use area protection and animal waste storage structures.

For each contract type, the bulk of staff time is spent in three stages: planning and applications, contracting, and implementation. For a simple contract, the total administrator time ranges from 20 to 27 h (including travel time). The most time-consuming task for a simple contract is planning and application. Implementation transaction costs for the simple contract are typically quite low, because technical assistance needs are low (or not required), and there are no engineering structures that require more sophisticated planning. Similarly, check-out is a simple task that generally takes around half an hour (plus travel time).

Staff hours increase substantially when moving from simple to moderate and complex contracts. Moderate and complex contracts require on average 45 to 83 staff hours in total, doubling to more than tripling staff requirements compared to the simple contract. Differences occur because of the number and complexity of items included in the contract; where, for example, the simple contract involves a single item (e.g. tree planting), a moderate contract typically involves 2–4 'items' (e.g. livestock exclusion fence, stream crossing and offstream watering facility). Also, more site visits occur during the planning stage for a moderate or complex contact. The largest percentage and absolute increase in staff time due to contract complexity occurs during the implementation stage. Staff costs for implementation increased 5 to 9 fold when moving to more complex contract types. Complex NRCS contracts usually require the input not only of the NRCS District Conservationist, but also a NRCS soil scientist and/or NRCS engineer. Further, complex contracts typically have more items (up to 8–10), and additional site visits can be required during implementation, whereas no site visits are generally required during implementation for the simple project.

Thus far only individual cost components for a single completed contract were considered. In reality, the situation is more complex because not all projects commenced ultimately result in a completed contract and conservation 'on the ground'. According to NRCS district staff, around 75 to 80% of producers who have gone through at least part of the inception and planning stages submit an application. Of submitted applications, only around 40 to 45% of projects are actually approved, mostly due to funding constraints. Finally, a small number of projects fail at the implementation stage. In 2013 6% of contracts (weighted average of 2013 Farm Bill programs in Virginia, weighted by proportion of contracts in each program) were 'cancelled' (landowner cancels before receiving funding) or 'terminated' (full implementation has not occurred but some funding has been received) (source: pers. comm. Patrick Vincent, NRCS Virginia). All in all, these attrition rates imply that for every contract successfully implemented, approximately 2 inceptions occur that ultimately are not successful. This result was corroborated confidentially by a private conservation provider in Virginia.

Estimates of the transactions costs of generating credits from working land BMPs were constructed based on the above time estimates and attrition rates, assuming a $75 per hour cost (wage rate that includes overheads) and accounting for time costs of the contracting process (see Table 2). We assume contracts are implemented over a 3 year period in which contracting takes place during years 1 and 2, and implementation (including 'check-out') takes place during years 2 and 3 (note that this does not include ex-post monitoring of the practice after installation is complete).

Estimated transactions costs vary significantly due to the complexity of the conservation activity (see Table 2). Simple contracts cost almost $3000 to complete after accounting for attrition. Complex contracts, however, are more than 2.9 times more costly to complete at around $8700. Attrition rates account for a significant portion of these costs. Project attrition can increase costs by 26% (complex contracts) to 37% (simple contract). The costs estimated developed here are broadly consistent with costs cited by another conservation organization operating in Virginia, whose estimates cannot be provided due to confidentiality. Hours estimates are also similar to figures provided by Falconer and Saunders (2002) for administration of conservation contracts at specific sites in England: they report that the typical contract requires 24 h of administrator staff time (not accounting for attrition).

On a relative cost comparison basis, the NRCS experience suggests that generation of term credits on working lands could involve considerably higher transactions costs than is currently the case for permanent land conversion credits in the Virginia WQT program. The NRCS simple contract—type (b) – land conversion to forest – best corresponds to the generation of permanent credits. The moderate and complex contract types, and simple contract—type (a) all relate to term projects that, if used for credit generation, would produce term credits. Apart from the lower transactions costs of a simple land conversion project, it is also worth noting that these costs are spread out 'in perpetuity' because the project generates permanent credits. In contrast, working lands contracts have limited duration and will require periodic renewal to generate an ongoing stream of term credits, increasing transactions costs on a 'per credit' basis (see following section).

In addition, the absolute estimates of staff time and transaction costs are likely to underestimate actual transaction costs in Virginia's nutrient trading program, for several reasons. First, a credit provider may have less extensive networks of contacts to locate prospective applicants compared to NRCS field staff, driving up transactions costs in the 'inception' stage. Second, the private credit provider must consider whether a particular project can profitably generate credits, producing additional transactions costs in the form of time spent to calculate credits and assess the market. Part of the credit calculation procedure would also require assessing whether nutrient credit baselines are met. Third, NRCS staff use fairly standard contracts with pre-constructed legal appendices that attach to all contracts, whereas credit providers may need to construct specific contracts for each credit-generating project

Table 2
Transactions costs estimates for development of conservation contracts[a].

Stage of project	Inception	Planning & application	Approval	Contracting	Implementation	Check-out	Cancellation & termination[d]	Total
Simple contract								
Cost per stage per single project ($NPV)[b]	145	541	158	469	256	108	188	**$1865**
Cost per stage per 1 completed project, accounting for attrition ($NPV)[c]	428	1280	374	499	272	108	12	**$2972**
Moderate contract								
Cost per stage per single project ($NPV)[b]	145	780	167	794	1260	188	188	**$3521**
Cost per stage per 1 completed project, accounting for attrition ($NPV)[c]	428	1845	394	845	1340	188	12	**$5051**
Complex contract								
Cost per stage per single project ($NPV)[b]	145	1234	202	1204	2244	1200	188	**$6417**
Cost per stage per 1 completed project, accounting for attrition ($NPV)[c]	428	2918	478	1281	2388	1200	12	**$8705**

[a] Based on average hours as per Table 1, monetarised assuming $75/h unit cost (wages + overhead, *not* reflective of NRCS unit costs), 5% discount rate.
[b] Estimate shows costs relating only to *completed* projects; costs of projects that were not completed ("false starts") not included.
[c] Estimate includes the costs of "false starts" (i.e. accounting for attrition).
[d] Cancellation & termination costs only apply to projects that are not completed.

used to meet regulatory requirements. Finally, the NRCS process covers only two of the four activities identified under 'credit creation' in Fig. 1 – that is, Table 2 includes transactions costs estimates for 'search for program participants' and 'service provision'. 'Certification' and 'credit registration and reporting' costs for VDEQ will be additional to NRCS's costs. While in a nutrient credit setting 'check-out' will still be done by the credit provider, the regulator/administrator (VDEQ) will be required to certify credit creation and register credits, which involves a site visit by the administrator (VDEQ reported an estimated average of 10.6 h for this step), plus additional activities beyond verifying correct BMP installation such as calculating the number of credits generated and registering them.

4.2. Transactions Costs of Ex-post Monitoring

Given that monitoring is a periodic activity occurring throughout the life of a credit project, its contribution to total program transactions costs can be relatively large. Features such as the *type* of monitoring employed, *frequency* (timing of monitoring actions) and *coverage* (proportion of relevant entities subject to a monitoring action) are important in determining the overall cost of a monitoring regime.

In order to explore the range of existing monitoring regimes employed in trading programs that involve NPS agriculture, we conducted detailed interviews with VDEQ and two other programs with experience monitoring transferable nutrient credits: the Willamette Partnership Rogue River Basin program in Oregon (temperature credits) and the Ohio River basin pilot trading project administered by the Electrical Power Research Institute (EPRI) (phosphorus and nitrogen (N) credits).

Program administrators interviewed distinguish between two levels or 'types' of monitoring:

- *On-site verification*: includes site visits where the regulatory agency (or designee) personally inspects the credit-generating project. Substantial written documentation may also be required, particularly in relation to ongoing practices such as nutrient management BMPs.
- *Remote verification*: the administrator makes use of information provided by the project implementer, third party verifiers, and/or remote sensing technology to verify service provision of the credit-generating project. Where the administrator relies on information from another party, monitoring outcomes may have a lower degree of certainty compared to 'on-site' verification. Remote sensing offers substantial potential to lower monitoring costs, but also faces tradeoffs between monitoring costs and information quality.

Table 3
Ex-post monitoring time estimates (hours per verification) for various programs.
Sources: pers. comm. Alan Brockenbrough, VDEQ; Willamette Partnership.

	Virginia DEQ (VSMP)	Willamette partnership (Oregon temperature trading program)		
		Program administrator	3rd party verifier	Total
Monitoring – remote verification (hours per verification)	0.25	4	2	6
Monitoring – on-site verification (hours per verification)	NA	10	20	30
Monitoring regime	Annual remote verification	On-site verification every 5 years; annual remote verification for interim years		

The precise nature of each of these monitoring types, and therefore the transactions costs involved, vary across programs. Table 3 reports on the monitoring regimes employed for the VSMP and the Oregon temperature trading program. EPRI did not provide quantitative estimates for the Ohio program but reported qualitatively.

Differences in the type and frequency of monitoring activities caused substantial differences in the transactions costs of monitoring, measured in hours of agency (and third party) time. In comparison to the VDEQ monitoring regime, Willamette Partnership has a moderately costly regime of on-site visits every 5 years, with remote verifications each year in between (project lifespan is 20 years) (pers. comm. Carrie Sannemann, Willamette Partnership, 2014). By contrast, EPRI conducts an on-site verification every year, and also contractually obligates SWCD agents who assist with project implementation to report any suspected breaches to EPRI during the usual course of their activities with producers in the project areas (pers. comm. Jessica Fox, EPRI, 2014). Although EPRI did not provide its own estimates, the monitoring regime described by EPRI would appear to entail substantially higher transactions costs than for the Oregon and Virginia programs.

Depending on the type of project being monitored, verification regimes may provide different levels of certainty for assuring the provision of nutrient control services, implying a possible tradeoff between costs and certainty. On-site verification is more likely to identify whether the project is still fully compliant with program requirements, especially for ongoing management practices such as nutrient management and decision agriculture. However, to the extent that practices are amenable to verification via remote sensing (which depends both on the practice being monitored and program rules/standards for the practice),[5] administrators may be able to rely more on remote verification without sacrificing certainty about project outcomes. Use of remote sensing together with geographic information systems (GIS) for monitoring (where feasible) has been recommended by the OECD's (2007) global study on policy-related transactions costs, as these technologies can help reduce error rates and the number of administrative staff required for monitoring activities. They are also less disruptive to producers, decreasing private transactions costs of participating in the program (Peterson et al., 2015).

Coverage refers to the proportion of projects that the monitoring actions are applied to. Within the programs analyzed, each project receives the same monitoring regime, so coverage is 100%. However, administrators could choose to randomly monitor a certain percentage of projects every year, such that any individual faces a *probability* (as opposed to a certainty) of being subject to a particular monitoring action in any given year. Reducing coverage may be one tool to decrease monitoring costs while still maintaining an acceptable level of compliance. However, reducing coverage may also reduce incentives to maintain compliant practices, resulting in a tradeoff between costs and compliance levels (Ozanne et al., 2001).

5. Implications: Relative Change in Transactions Costs from Expansion into Working Lands Credits

This section brings together information from previous sections to estimate indicative per project transactions costs for expanding NPS credits to term credits from working agricultural lands. Transactions costs associated with credit creation (including certification and credit registration and reporting) and ex-post monitoring are estimated for 3 different types of credit projects: permanent land conversion projects, term projects associated with agricultural *structural* BMPs, and term projects associated with agricultural *management* BMPs. The three credit project types differ in terms of term length, project complexity, and ex-post monitoring requirements. Credit creation refers to the set of activities undertaken to install the credit-generating practice(s) (see Fig. 1). Within this broad category, we separate out ‘certification’ and ‘credit registration and reporting’ costs, which we assume are borne by the program administrator, from ‘search for program participants’ and ‘service provision’ costs, which we assume are borne by the credit provider. Ex-post monitoring is the on-going verification that the practice(s) continues to be in place in a period *after* the original credit credits have been certified and registered.

Transactions costs associated with permanent credits from a land conversion project are used as a reference case against which costs of term projects can be compared. For this case, we assume general costs and attrition rates based on what is incurred by a NRCS land conversion project (i.e. a *simple contract – type (a)*). VDEQ certification costs are constructed based on the average of certification site visit hours plus an additional 4 h for administrative paperwork.[6] VDEQ credit registration and reporting costs are assumed to be 1 h per contract.[7] The ex-post monitoring regime is assumed to consist of remote annual monitoring. The credit creation (including certification) and verification costs are then discounted and summed over a 30 year time period to generate present value and annualized transaction cost estimates.

We then construct two scenarios that represent low- and high-cost term projects that could be used generate credits from agricultural working lands. For purposes of comparison, we arbitrarily assume each type of project generates the same number of P credits (60 lbs./yr). The low cost term credit project assumes a medium-complex 10 year contract consisting of structural BMPs (renewed 3 times to generate a 30 year stream of credits). We assume that this project requires re-certification each time the contract is renewed (i.e. in years 10 and 20), plus onsite verification every 5 years and annual remote interim verification. We assume the hours required to certify (and re-certify) are increased compared to the case of perpetual credits (see notes accompanying Table 4).

The high cost term project is defined to represent management style BMP practices (cover crops, reduced fertilizer application, etc.). This project type is assumed to require re-certification every 3 years (10 times over 30 years) and full annual verification in interim years. Again, complex projects require proportionally more hours for (re-) certification.

For the 10- and 3-year term credits, we also construct lower and upper bound based on the degree to which the transactions costs associated with ‘credit creation’ are incurred again each time the credits expire. In the lower bound estimate, we assume that only the ‘certification’ and ‘credit registration and reporting’ costs are re-incurred; this is equivalent to assuming that the initial contracts covered the entire 30 year period and specified that the credit-generating practice is to be re-installed (or, in the case of management practices, continued) at the required intervals. Therefore, although the program administrator (or designated third party) will incur transactions costs across the period to verify that the initial contracts are adhered to and to create new term credits as required, this lower bound scenario assumes no further ‘credit creation’ transactions costs accrue to the credit provider. In the upper bound estimate, we assume that the entirety of ‘credit creation’ transactions costs are incurred again each time after the credit term expires; this is equivalent to assuming the credit provider needs to find new participants each time. In reality, somewhere between the two would be expected to occur.

The estimated present value and annualized project costs for all scenarios are presented in Table 4. Together, project complexity, term length, and monitoring regime can have a dramatic effect on administrative transaction costs. Given the initial assumptions of the analysis, total transactions costs of credit creation, certification and monitoring for the 10-year term credits and 3-year term credits are around 2–3 and 7–16 times higher, respectively, than permanent credits. The transaction costs associated with term credits depend substantially on whether credit creation transactions costs need to be re-incurred when the credit term expires. Since farms are dynamic enterprises, it seems reasonable to expect at least some re-creation and/or re-certification costs to occur when re-evaluating the crediting of conservation management practices. In the case of 3 year term credits, the transaction costs implications are further magnified because complex projects are two to three times more costly to implement. Ex-post monitoring costs can also add substantially to overall transaction costs. Monitoring costs for 3-year term credits with annual on-site verification are 27 times higher compared to monitoring costs of perpetual credits.

Assuming 60 P credits are generated, annualized transactions costs per credit are $4, $9–$14 and $30–$69, respectively, for the permanent, 10-year, and 3-year credits (per pound). These transactions costs appear to be inversely related to the estimated cost of control. Several studies note that management practices have low nutrient abatement costs, typically less than $50 per pound of phosphorus (Cools et al., 2011; Shortle et al., 2014). The results generated here, however, suggest that transactions costs could significantly undercut the apparent cost-effectiveness of these nutrient control alternatives.

[5] For example, remote sensing for a permanent land conversion might be satisfactory if program rules specify a simple practice standard such as number of stems per acre; if more complex rules are in place, for example rules relating to erosion levels or type of trees planted, monitoring via remote sensing may be less adequate.

[6] This estimate comes from Willamette Partnership, who reported certification of 10 h for the administrator (very similar to VDEQ's 10.6 h average for site visits), and 4 h for administrator ‘validation’ of paperwork (pers. comm. Carrie Sannermann, Willamette Partnership, 2014).

[7] Interviewees did not provide quantitative data for this activity. However, the current VSMP credit registry is a simple spreadsheet available on VDEQ's website (see http://www.deq.virginia.gov/Portals/0/DEQ/Water/PollutionDischargeElimination/NonpointCreditRegistry.pdf, accessed April 2016), and therefore we assume that this activity is not a costly one.

Table 4
Comparison of project transactions costs from permanent and term projects.

Project type	'Permanent' credits	10-Year fixed term credits	3-Year fixed term credits
Project description	Simple project, costs counted for 30 years of project life	Moderate project complexity; project life is 10 years (renewed 2 times for 30 year period)	Complex project complexity; project life is 3 years (renewed 10 times for 30 year period)
P Credits generated (per year)	60	60	60
Ex-post regime description ($NPV)	No re-certification; annual remote verification over project life (30 years)	Project is re-certified/recreated† in years 10 & 20; on-site verification in years 5, 15 and 25; remote verification in interim years	Project is re-certified/recreated† every 3 years; on-site verification in interim years
Initial credit creation costs ($NPV) (accounting for attrition)	$3752	$6201	$10,355
Ex-post credit re-creation costs ($NPV) (accounting for attrition)	$0	$1127 – $6144	$12,309 – $48,096
Ex-post monitoring costs ($NPV)	$192	$937	$5248
Total ($NPV)	$3945	$8216 – $13,283	$27,679 – $63,698
Annualized cost ($/year)	$257	$534 – $864	$1801 – $4144
Annualized cost per credit ($/lb./year)	$4	$9 – $14	$30 – $69

Assumptions: Credit creation costs based on NRCS estimates + 1 h for Registering & Reporting Credit Creation (all project types) + Certification costs as follows: permanent credits: 10.6 h; 10-year credits: 18 h; 3-year credits: 28 h. Monitoring costs: remote verification (all project types): 0.25 h; on site verification (all types): 10 h. Travel costs for site visits as per Table 2, plus 1 h per on-site verification, 1 h per re-certification (where re-certification occurs without ex-post credit creation). NPV estimates assume a 5% discount rate. Wage rates: $75/h unit cost for credit provider; $50/h unit cost for program administrator. Activities undertaken by administrator are registering & reporting credit creation, certification and ex-post monitoring. † Lower bound: project is re-certified only; upper bound estimate additionally assumes entirely new credits must be created when the first term of credits expire, thus re-incurring all credit creation costs.

6. Conclusion

Currently, overall transactions costs for nutrient trades involving perpetual term phosphorus credit in Virginia do not appear to act as a barrier to trade. The levels of transactions costs experienced to date are modest largely due to the type of activities currently being credited: simple land conversions. Land conversion projects are straight-forward to plan and evaluate, as Virginia provides clear and uncomplicated procedures to quantify credits and projects typically do not involve the implementation and consideration of baseline practices. Verification and monitoring is straight-forward and can be done via remote monitoring of tree cover.

In contrast, if credits were to be generated using management, vegetative, and/or structural practices, the procedures will become more complex to assess and monitor. Based on best available evidence gathered from other similar programs, the administrative transactions costs of creating credits on working agricultural lands using management and structural BMPs are likely to be significantly more costly on a per project basis relative to credits generated from land conversions (the dominant agricultural NPS credit-generating practice in Virginia). It is estimated that it may be 2 to 16 times costlier to the administrator and credit provider to generate credits from working land BMPs than for land conversion and retirement. Costs need to be compared to the relative value created in terms of nutrient reductions. For example, the estimated transactions costs of term credits could exceed the costs of BMP implementation and are several times larger than the price of nutrient credits currently being charged under the point source trading program.

Reductions in transactions costs could be achieved through alternative verification processes. For instance, in our analysis, monitoring costs were reduced 82% by allowing interim remote self-reporting of BMP status for 4 out of 5 years, and by 96% if all monitoring is undertaken remotely. Remote sensing technologies offer opportunities for substantial reductions in verification costs for amenable practices (although some practices such as certain management practices will be difficult or impossible to verify remotely). These results suggest an important cost/risk tradeoff between verification cost and compliance certainty for program designers to consider. Little is currently known about the efficacy of alternative verification regimes to deter noncompliance and to identify instances of noncompliance. Behavioral economic research may provide insight into how compliance can be maintained without requiring annual onsite verification. Nevertheless, administrators should explicitly recognize tradeoffs between transactions costs and certainty, and strike a balance that is appropriate to the program's needs while continuing to investigate other methods to mitigate the costs of uncertainty.

Transactions costs of particular credit-generating projects should be accounted for alongside implementation costs, to ensure that comparisons between projects or BMPs are not biased towards those with low abatement costs but high transactions costs. The estimates provided in this study likely present a lower bound for the actual costs involved. Transactions costs of credit creation were drawn from NRCS – an organization that has long and comprehensive experience with contracting for conservation planning, but whose programs do not produce water quality credits for regulatory compliance. It is likely that credit creation costs experienced by WQT program administrators and credit providers will be higher, partly due to their relative inexperience but also because of the significant cost burden of monitoring credit-generating projects to a sufficient standard for a regulated program. Furthermore, our estimates omit certain categories of administrative transactions costs (e.g. program design costs, market transactions costs), and do not include any measure of transactions costs incurred directly by the buyer or landowner. On the other hand, bundling together multiple on-farm practices into single contracts may offer some potential to economize on transaction costs (economies of scope). More work is needed to measure these costs to provide a comprehensive picture of the true transactions costs of WQT programs.

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