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The US Conservation Reserve Program: The evolution of an enrollment mechanism

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ABSTRACT

The United States Department of Agriculture's Conservation Reserve Program (CRP) has evolved from near open enrollment, to competitive enrollment, and now to a mixture of competitive and targeted enrollment. This paper reviews the history of the CRP and the evolution of its enrollment mechanism. I discuss the use of bid caps and the Environmental Benefits Index bid ranking mechanism in the "general" CRP; and the use of highly targeted, but non-competitive, "continuous" CRP. Possible challenges of these designs are discussed, and alternative auction mechanisms are considered that could be more cost effective.

1. Introduction

Created by the Food Security Act of 1985, the United States Department of Agriculture's Conservation Reserve Program (CRP) establishes contracts with agricultural producers to retire highly erodible and other environmentally sensitive cropland and pasture. Farmland accepted into the program for a 10–15-year contract period are converted to grass, trees, wildlife cover, or other vegetation that provide environmental benefits. By 1991, more than 12.9 million hectares (32 million acres) were enrolled in the program, with a peak enrollment of 14.9 million ha occurring in 2007. The Agricultural Act of 2014 extended the CRP, setting a maximum enrollment of 9.7 million ha in 2017. As of April 2015, the CRP enrolls 9.8 million ha at a cost of more than $1.8 billion per year (USDA FSA, 2015a).

The program has led to improvements in a variety of environmental services (Barbarika, 2011; Allen and Vandever, 2005), such as wildlife habitat (Allen and Vandever, 2012) and water quality (FAPRI, 2007). Benefit-cost analyses, although complicated by the range of outputs provided by the program, indicate aggregate benefits comparable to costs (Hansen, 2007; Ribaudo et al., 2001; Feather et al., 1998; USDA FSA, 2014a).

Over time the program's size and goals have evolved, with early emphasis on limiting erosion now complemented by wildlife, water and air quality, and other conservation goals (for detailed reviews of the CRP's history, see Ferris and Siikamaki, 2009; Stubbs, 2013; or Karousakis and Brooke, 2010). This evolution continues, driven by changes in legislative mandates, commodity markets, and environmental concerns. And as the program evolves, so has its enrollment mechanism.

As a voluntary program, the CRP needs an enrollment mechanism: a means to elicit offers, and to choose which offers to accept. The goals of any enrollment mechanism include minimizing program expenditures to achieve a targeted level of benefits, or maximizing benefits within a set budget; encouraging broad participation; inducing adoption of enhanced environmental practices; and minimizing impacts on production.

When designing an enrollment mechanism, the CRP's fundamental features need to be considered. These include optional participation, heterogeneous costs across different landowners, the capability of landowners to increase the environmental values of offered lands, and the limited informa-

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tion on the opportunity cost of the land available to the USDA.

This paper reviews the evolution of the CRP's enrollment mechanism. I start with a review of the status and trends in the CRP; in terms of acreage, costs, and offer rates. The next section discusses in detail the attributes of the CRP's enrollment mechanism. The paper then considers limitations of the current designs, and possible improvements.

2. CRP status and trends

The Conservation Reserve Program is not the first US agricultural land retirement program (Heimlich, 2003). From the 1930's until the mid-70s, several different programs led to the retirement of cropland. With a primary goal of production control, these programs fluctuated in size, and typically enrolled land in short periods (Ferris and Siikamaki, 2009). The modern CRP systematically differs from these earlier programs both in its focus on erosion and other environmental concerns, and in the time-span and management practices required.

Upon its inception the CRP was mandated to enroll 16.2–18.2 million ha by the end of the 1990. Enrollments started in 1986, and by 1989 enrollment was 13.6 million ha (33.6 million acres). Enrollment occurred during nine separate "general signups"; designated periods during which landowners with eligible cropland could offer fields they wished to enroll at a chosen rental rate. This essential feature, of enrollment occurring during general signups, has been maintained to the present. And, as dictated in the original legislation, the focus of the CRP has always been on land devoted primarily to crop production (USDA, 1985).

During this 1986–1989 time span, eligibility was determined by erodiblity; with about 41 million ha (of about 162 million ha) of cropland eligible. Payment was based on regional (multi county) Maximum Acceptable Rental Rates (MARR); any offer submitted by a farmer with a requested rental rate less than their MARR was accepted (Osborn et al., 1995). This mechanism was criticized as leading to higher program costs, as landowners within a region learned the likely MARR and bid accordingly (GAO, 1989). Furthermore, the focus on erodiblity led to enrollment of lands that did not necessarily benefit water quality, wildlife, and other environmental goods and services (Ribaudo et al., 2001).

The Food Agriculture, Conservation and Reform Act of 1990 extended the CRP, and emphasized the importance of goals other than erosion control. Over the next several years an additional 1.1 million ha were enrolled, and the enrollment mechanisms used were substantially modified. The MARR was replaced with a parcel-specific "Soil Rental Rate" (SRR), that was computed using parcel-specific soil productivity measures as well as county-level estimates of non-irrigated cropland rental rates (Osborn, 1997). Furthermore, each parcel was assigned a score calculated using a multi-factor Environmental Benefits Index (EBI). The EBI incorporated several factors beyond soil erodibility, including surface and ground water improvements as well as a parcel's location in a priority conservation area. Both of these concepts – "bid caps" based on soil specific rental rates (SRR) and offer rankings based on an EBI—continue to be part of the CRP's current enrollment mechanism.

However, this early version of a SRR and an EBI had unique features that were dropped in later years. First, the EBI was constructed as a benefit-cost ratio. Second, in signups 10, 11 and 12, SRRs were not revealed to landowners — these SRRs (like the MARRs they replaced) were similar to a blind reserve prices in a traditional auction. A large fraction of offers were rejected due to bids that exceeded this cap, possibly due to the expectation of landowners about acceptable bids formed when MARR's were used as bid caps. As a consequence of this high rejection rate, the EBI was not binding (implicitly, a minimum EBI score of 0 was used, so all bids below their SRR bid cap were accepted).

The CRP was re-authorized in the Federal Agriculture Improvement and Reform (FAIR) Act of 1996, which reduced the maximum program size to 14.7 million ha. Several changes occurred at the administrative level. Conservation Priority Areas, consisting of State and federally defined regions where cropland did not have to meet erodibility standards, were created or greatly expanded—leading to an estimated additional 39.2 million ha of cropland becoming eligible for the CRP. The EBI was overhauled, with a number of factors given explicit weights. In addition, cost was incorporated as a weight—it entered the function additively rather than being used to form a benefit-cost ratio (Heimlich, 2003).

That is, rather than a benefit-cost ratio, the EBI is better described as a *cost adjusted* measure that uses weights to capture the importance of a number of factors, including cost. The SRR continued to be based on estimates of county average non-irrigated cropland rental rates, with parcel-specific adjustments based on the soil productivity of a parcel's dominant soil type. However, it was revealed to farmers—they knew what their bid cap was. Fig. 1 shows the geographic distribution of Soil Rental Rates circa 2012.

The next few years also saw the expiration of the bulk of the original contracts. During the next several signups this "cost adjusted" EBI, along with parcel-specific SRRs, were core features of the enrollment mechanism. By 2000, over 10.5 million ha of land were enrolled (or re-enrolled) in the program under this mechanism.

This period also sees the advent of a different form of CRP: the continuous CRP. Continuous CRP is meant to enroll lands with high environmental benefits (including lands where the EBI does not do a good job of reflecting the parcel's environmental impact). Thus, its enrollment mechanism is substantially different from the general signup. As the name implies, continuous signup is open all year—eligible acres can be offered at any time. However, eligibility rules are more stringent then general signup, and there is no competition: if an offered parcel is eligible, it will automatically be accepted into continuous signup (and receives a fixed rental payment based on the parcel's SRR).

The next decade saw minor changes in the EBI factors and scoring, and changes in program eligibility (Hellerstein, 2006). Acreage enrolled under continuous signup steadily increased. This included initiatives (such as the Farmable Wetlands Program); and the Conservation Reserve Enhancement Program – a subset of continuous CRP comprising a number of state/Federal collaborations aimed at local concerns.

Enrollment reached a peak of 14.9 million ha in 2007. In the 4 years starting in 2007, 10.9 million ha of CRP contracts were to expire. For a variety of reasons, including the desire to smooth expirations over time, USDA instituted a re-enrollment and extension (REX) initiative. Based on its EBI score, parcels were offered automatic re-enrollment or 2–5 year extensions (re-enrollment was offered only to contracts in the top quintile of EBI scores). Approximately 82% of expiring acreage took advantage of this REX opportunity (USDA FSA, 2007). .

The Food, Conservation, and Energy Act of 2008 extended authorization for the CRP, but reduced program size to 12.9 million ha. The reduction in program size meant that the program could not re-enroll (or replace) all the acres set to expire in the years following 2010. Between 2010 and 2013, contracts containing 5.74 million ha expired, while contracts covering 4.7 million ha were issued (about 71% of which are reenrollments). Although overall acreage decreased, continuous signup acreage increased by 0.5 million ha (USDA FSA, 2013c). In addition, the data collection used to calculate SRRs was modified, with USDA instructed to conduct yearly surveys of county level non-irrigated cropland rental rates

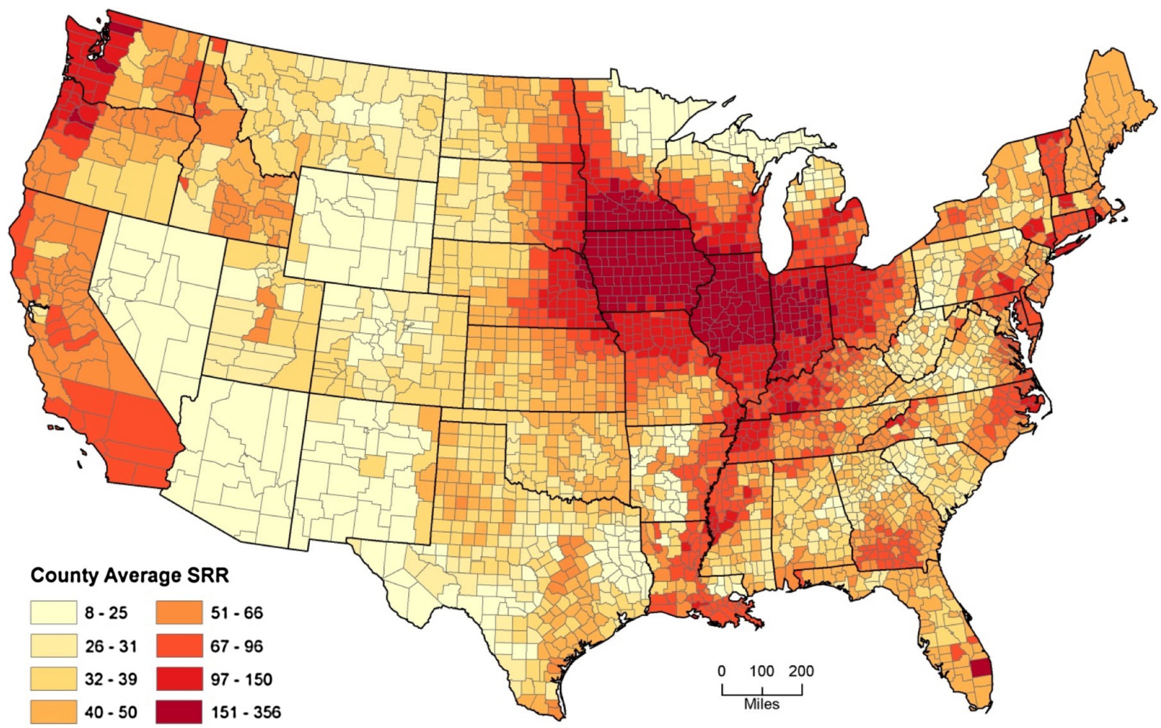

Fig. 1. County Average Soil Rental Rate (SRR), circa 2012.
Source: USDA Farm Services Agency (FSA). Note the mean SRR is $126/ha ($51/acre), the median is $96/ha, and the 10 and 90 percentiles are $62/ha and $240/ha respectively.

(USDA NASS, 2015), rather than the prior practice of using estimates derived from opinions of local experts.

With the passage of the Agricultural Act of 2014, the program's size will be reduced to a maximum of 9.7 million ha in 2017 (Claassen, 2014; NSAC, 2013)

As of April 2015, the CRP enrolls 9.8 million ha (USDA FSA, 2015a; USDA FSA, 2014b). About 7.3 million ha are enrolled under general signup (with average rental rates of about $127 per ha), while continuous signups accounts for 2.5 million ha (at an average per-ha rental rate of about $257).

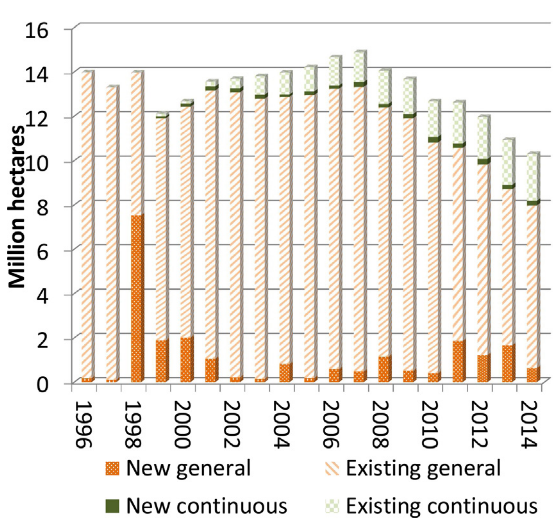

Fig. 2. Recent trends in CRP enrollment: shrinking size, with "continuous" enrollment a growing share.
Source: USDA/ERS analysis of CRP contract data, as of end of fiscal year. Note that "new" means new contracts – many of which are re-enrollments.

2.1. CRP enrollment trends

Fig. 2 displays the trend in CRP acreage since 1997; what one might call the "modern CRP"; the CRP influenced by the Environmental Benefits Index (discussed below). The figure reports acreage enrolled by either the competitive "general" signup mechanism, or the targeted "continuous" signup. Note the decrease since 2007, which is contemporaneous with both the shrinkage in the national acreage cap and the increase in commodity prices starting around 2007 (see Fig. 3). Fig. 3 also includes a trend line for the average SRR. Note that although the SRR is based on annual surveys (USDA NASS, 2015), overall it has not always tracked trends in commodity prices.

Enrollment in the general signup occurs during discrete time periods. These typically occur in the spring, and last for several weeks; with actual enrollment starting October 1 of the same year. Expiring CRP contracts are automatically eligible for general signup, but must compete for acceptance. As shown in Fig. 4, most con-

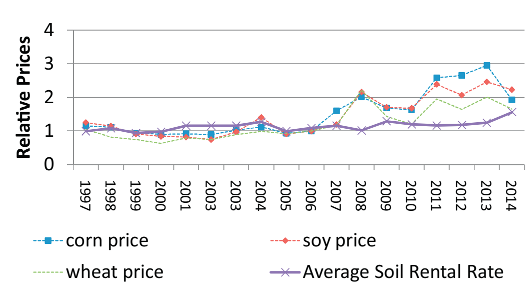

Fig. 3. Index of commodity prices and average Soil Rental Rate (relative to 2006 values).
Notes: Average Soil Rental Rate is based on data from general signup contracts that started in a given year (hence may be biased measures of the average Soil Rental Rate across all eligible lands).
Source: USDA/FSA data and data from http://www.indexmundi.com/commodities/
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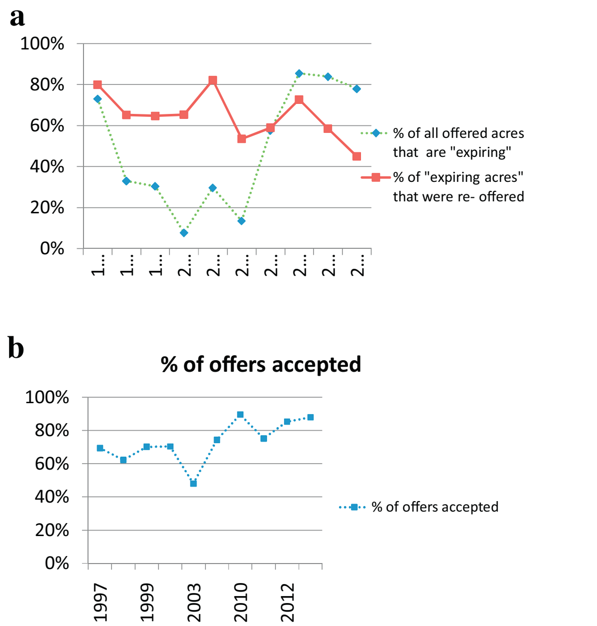

Fig. 4. Trends in CRP offer and acceptance rates.
Notes: (a) Expiring general signup parcels tend to be re-offered, and sometimes are the dominant set of offered acres. (b) Acceptance rates have increased in recent years.
Source: USDA/ERS analysis of CRP contract and offer data.

tract holders re-offer their land, and in many years most offers accepted in a general signup are from expiring contract holders. From 1997–2006, the acceptance rate of all general signup offers averaged about 65%, and jumped to an average of 85% in 2010.

The overall trends suggest that prior to 2007, before the jump in commodity prices, the CRP was in a stable pattern. Most contract holders were interested in staying in the program, and program acreage was stable (albeit with a rising proportion enrolled via continuous signup). The increase in commodity prices after 2006 was accompanied by decreasing interest in the program, both on the part of legislators and rural landowners. CRP contract holders are still by and large interested in re-enrolling, but not as strongly as in the past.

3. The CRP enrollment mechanism: general signup

Offers for enrollment into the CRP's general signup consist of a request by the landowner for an annual rental payment in exchange for implementation of a proposed cover practice on a specific parcel of land. All rent requests are capped using the parcel's SRR – which is known by the landowner. More precisely, an offer to the CRP can contain several fields, where each field has its own SRR (since each field may have different soil productivity). A single SRR that applies to each acre included in the offer is calculated using a acreage weighted average of the SRRs from the offer's 3 predominant soil types. Offers are ranked according to an Environmental Benefits Index (EBI) that includes factors accounting for various environmental services, and a cost component that depends on the landowner's asking price. Offers with the highest EBI scores are then accepted into the program.

These design elements—what can be called the procurement auction (or, "reverse" auction) for retiring cropland to obtain environmental services—have a powerful influence on the parcels that have been selected into the program, how much landowners are paid, and thus how well the CRP achieves its objectives. Table 1 lists key features of the CRP's auction mechanism. Below, we discuss several of these features: contract length, acreage caps and repeated auctions, one time sealed bids, the EBI, and the SRR. We pay particular attention to the EBI and the SRR.

Table 1
Auction features of the CRP General Signup.

Characteristic	Implementation
Auction type	One-sided, sealed bid procurement auction
Ranking mechanism	Environmental Benefits Index (EBI) that includes cost
Acreage target	Rough acreage target, rather than budget cap
Bidding cap	The Soil Rental Rate (SRR). This is predetermined for all eligible parcels, and is revealed to participant before an offer is submitted
Acreage cap	CRP acreage can not exceed 25% of cropland in a county
Number of rounds	Single binding round, periodic auctions. However, general signups occur on a more or less yearly basis, and rejected offers can be resubmitted (with possible modifications to bid and cover practices) in later years.
Pricing rule	Discriminatory (bid price paid).
Number of bidders	Unknown prior to auction

3.1. Contract length

The 10–15 year contract required in CRP has costs and benefits. On one hand, a long-term contract can be beneficial from an environmental standpoint if it takes time to establish native covers, wildlife habitats or buffer strips and begin accruing environmental benefits. Longer contracts may also induce greater participation; such as in higher risk regions where longer term contracts may provide a certainty equivalent benefit for land owners who would otherwise face revenue risk in the land rental market (Wallander et al., 2013).

On the other hand, landowners may require greater rental payments given they are locked into the program for a long period of time (Wu and Lin, 2010). In addition, longer contracts may reduce flexibility, should public preferences for environmental amenities change (hence what types of land should be retired).

3.2. One-time sealed bids/discriminative auction

The CRP uses a discriminative auction where landowners have a single opportunity to privately submit their bids (bids are not announced publicly), and that bid cannot be revised. This feature of the enrollment process also involves tradeoffs. Research (Cason and Gangadharan, 2004; Schilizzi and Latacz-Lohmann, 2007), suggests that discriminative reverse auctions for multiple units (each chosen offer 'receives its own bid') auctions are more cost effective than open auctions (where each chosen offer receives the same payment, such as the payment given to the most expensive accepted offer).

However, if landowners could revise their offers after observing a first round of bids, those not accepted in an initial round may be willing to adjust their cover practices or rent requests. Conversely, if farmers knew additional rounds of bidding would occur, they would have less incentive to bid competitively in the initial round (Latacz-Lohmann and Schilizzi, 2007). Since general signups occur on a more or less yearly basis, landowners who are willing to resubmit rejected offers in later years have an opportunity to adjust their bids.

3.3. Environmental Benefits Index. (EBI)

The EBI is a formula that scores each parcel offered for enrollment into CRP. This scoring mechanism, perhaps the most crucial design element of the CRP, assigns points to a number of different factors, including cost (USDA FSA, 2013a). These points implicitly value the program's different environmental goals, although those implicit valuations can be difficult to discern given the complexity of the scoring formula.

Although the EBI can change from year to year, its core components have been generally constant over time (USDA FSA, 2012). These include coequal weighting given to wildlife, water quality, and erosion control; and the inclusion of cost as an important (but not extremely large) additive factor.

The points awarded for each factor are sometimes, but not always, influenced by decisions of the offer maker. For example, the points awarded to the "erodibility" factor are "exogenous": it is based on an index computed using soil characteristics, over which the offer maker has no control. In contrast, the wildlife factor is "endogenous": points assigned to it can be changed by choosing to install a more beneficial (though perhaps more costly) conservation practice (Johnson and Clark, 2000). This mix of exogenous and endogenous scoring, that varies over parcels, will influence bidding behavior (Jacobs et al., 2014).

With one exception, for a candidate parcel the landowner knows the points assigned to each factor. The exception is the cost factor—the EBI cost weight (which transforms a requested rental rate into EBI points) is determined after all offers have been received.

In practice, the EBI reflects a balancing of potentially conflicting interests and conservation goals. In particular, the assignation of points is informed by, but does not rely on, measures of the ecosystem services that cropland retirement may provide. This assignation is largely the result of a "delphic process" based on a mixture of expert opinion, scientific data, and stakeholder inputs. Although valuation of benefit flows due to the CRP has been used in ex-post analysis of the impacts of the program (Hansen, 2007); it has not been a prominent feature when choosing what factors to include in the EBI (or how many points each factor receives).

In addition, although the EBI generates a continuous cardinal measure, its primary purpose is ordinal. The EBI is used to provide a structured means for selecting offers, rather than producing an accurate cardinal measure of the net value of each offer. In practice, at the conclusion of a general signup, CRP program administrators choose a "cutoff"—with all offers having an EBI score greater than this cutoff accepted.

Ever since 1997, a peculiar feature of the EBI has been its use of cost as one of several factors, instead of as the denominator in a benefit/cost ratio. Basic economic reasoning suggests that rankings should use benefit/cost ratios, rather than this additive ("cost adjusted") measure (Duke et al., 2013; Ferraro, 2003). However, if a lack of information makes it difficult to accurately measure the value of the ecosystem services provided by a retired acre, then using an available benefit/cost measure may be problematic. For example, if regional discrepancies in benefit values are not well captured within the EBI, then using a benefit/cost ratio could lead to inordinately large enrollment of land in regions with lower agricultural productivity (hence lower cost).

With an additive cost factor, especially one whose value can be publically determined after all offers are received, program administrators can choose to favor lower cost lands (by increasing the weight given to cost), or more environmentally beneficial lands (by decreasing the weight). This feature provides some programmatic flexibility—it allows program managers to respond to the set of offers submitted in each general signup (Hamilton, 2010). Conversely, this adds ambiguity to the landowner's decision, as their actual EBI scores cannot be fully known when they submit their bid. This ambiguity could dissuade some potential participants (for examples of the impacts of ambiguity, see Congdon et al., 2011; or Beshears et al., 2013). However, in practice the cost factor weight has been fairly stable over time (USDA FSA, 2012) – which may reduce both its "ambiguity" and "flexibility" impacts.

3.4. Bid caps

Bid caps (the SRRs) have several powerful effects on CRP. Most obviously the caps limit how much any individual landowner might gain from the program. How well does this bid cap mechanism auction work?

Given the national scope of the program—with upwards of 100 million eligible ha—the actual construction of parcel-specific bid caps is non-trivial. The USDA uses a combination of estimates of county averages of non-irrigated cropland rental rates, and adjusts these using a measure of a parcel's soil productivity. The county averages are recalculated every year using updated estimates provided by the USDA's National Agricultural Statistical Service (USDA NASS, 2015), These values are reported before signups occur. County officials can formally dispute these estimates using alternative methods (such as cost-share equivalents), comparison to neighboring counties, and publically filed rental agreements. The USDA examines these appeals and determines on a case by case basis if any adjustment is needed. This is a complex task, and its results have been subject to critique (USDA OIG, 2009). Issues include whether the USDA is able to draw proper conclusions from sparse data and whether "soil productivity" adjustments are determined accurately. Furthermore there are issues of what the appropriate market is. Is the proper rental rate computed from all rental lands, or should lands that are likely to be rented to large institutions (i.e., the USDA) be used. That is, if rural land transactions are often characterized by long term landowner-tenant relationships, and if such lands are not likely to be offered to the program, should they be included in average rental rate calculations?

A goal of bid caps is to limit excess payments to parcels with low agricultural value. In contrast, for simpler auctions that do not use observable information on costs to set bid caps, theoretical (Wu and Babcock, 1996) and experimental work (Arnold et al., 2013) indicate that heterogeneity generates a systematic tendency for landowners of lower quality parcels to make offers that yield substantial information rents (extra profits due to information on the attributes of their land known only by the landowner).

A means for evaluating how well the SRR performs is to estimate the "rent premium" received by the landowners: the amount of excess profit they obtain if the government's payment exceeds the parcel's actual opportunity cost. This is possible if the bid cap overstates the value of the parcel. Kirwan et al. (2005) offered an empirical estimate of such rent premiums generated in the CRP, estimating that between 10% and 40% of the program expenditures went to rent premiums.

However, bid caps that are set too low may present a bigger problem. Inappropriately low bid caps may inhibit the extent to which CRP achieves environmental goals in a cost-effective manner, because landowners with attractive parcels (parcels with a high EBI) will be dissuaded from submitting an offer if their usual farming activities provide greater net revenue than their bid cap. This can effect both low and high cost (low and high net agricultural productivity) lands. As illustrated by Hellerstein and Higgins (2015), in a program with an acreage goal, unbiased (but imperfect) bid caps can lead to a reduced number of low cost offers that must be offset by acceptance of higher cost offers—which can lead to an increase in total program costs.

Bid caps can also limit EBI-improving cover practices on parcels offered and accepted into the program. This happens because some landowners requesting the highest-possible capped rate (i.e.; those requesting a rental rate equal to their SRR) may be nearly certain of their acceptance even without an EBI-improving cover practice. If there were no bid cap, the landowner could compensate a more costly EBI-enhancing cover practice with a higher requested rent.

Hellerstein and Higgins (2010) investigate these points with a set of lab experiments using induced values. Participants were

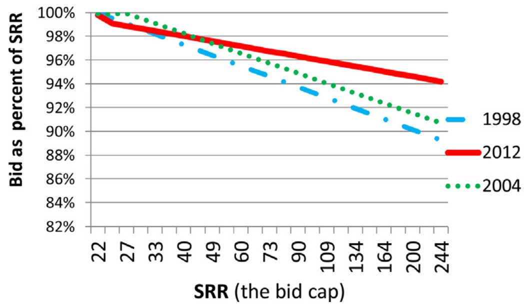

Fig. 5. Bids tend to be close to bid caps, especially in later signups.
Source: USDA/ERS analysis of CRP offer data. Points on the curves represent average "bids as percent of SRR" for all offers with a given SRR. More precisely, averages are over contracts that are assigned to one of 25 "bins", with each bin covering a non-overlapping ranges of SRRs.

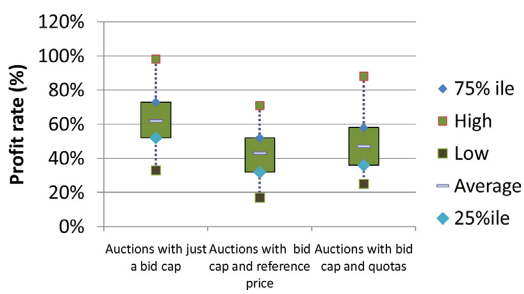

Fig. 6. Average profit rate for three different auction mechanisms.
Notes: the bid caps used in the 2nd (reference price), and 3rd (quota), rounds were well above the bid caps used in the first rounds.
Source: Hellerstein et al. (2015b).

given "tickets", where each ticket has a pre-assigned "cost". Participants can sell their tickets through a sealed bid discriminative auction; where both the asking price and costly "quality improvements" are specified. They found that bid caps set at a low level (80% of the maximum possible cost of a "ticket") have higher acquisition costs than setting a cap 20% above this maximum possible cost. They also find that "quality improvements" are reduced as bid caps become more stringent—since low cost "tickets" (who are almost certain to be accepted even if they request their bid cap) have no incentive to invest in better quality. Thus, aggressive use of bid caps may be counterproductive, especially when sellers can improve quality as well as lower their bid.

3.5. Acreage target/repeated auctions

The CRP's enabling legislation sets an acreage cap, and does not set an overall budget ceiling. Thus, in each general signup the program administrators decide how many acres to enroll (though not all available acres are enrolled, given the need to have capacity to enroll lands under ongoing CREP and continuous initiatives).

With repeated auctions occurring on a more or less yearly basis, landowner rents can increase as they gain experience and garner more information (Latacz-Lohmann and Schilizzi, 2007; Messer et al., 2013). Additionally, sellers may tend to bid more aggressively when acreage targeting is used in a repeated auction setting (Whitten and Langston, 2013). As shown in Fig. 5, this effect may be present in the CRP. In later signups, bids are closer to their bid cap. Note that Fig. 5 also shows that in all signups, lower productivity lands (with smaller SRR values) have bids closer to their bid cap.

Table 2
Results of alternative auction experiments.

The auction design	Findings...
Quota auction (no quality improvement)	With a non-binding bid cap in place, allowing only a certain percent of each seller group to be accepted led to a 9-percent reduction in costs.
Quota auction (quality improvement)	The cost of achieving a quality-adjusted target was reduced by 14 percent compared to similar auctions where just a bid cap was used.
Reference price auction (quality improvement)	With a non-binding bid cap in place, using a reference price when determining which tickets to accept yields an 18-percent cost reduction.

Source: Hellerstein et al. (2015b).

4. Possibilities for alternative auctions

When considering a conservation policy, it is useful to consider the importance of social welfare maximization (in a Pareto sense). Maximizing the aggregate value of an ecosystem service (abstracting from the distribution of benefits) can be achieved by setting its price equal to its social value. For example, if the managers of a conservation program know the monetized value of the reduction in soil erosion due to retiring an acre of farmland, a uniform price equal to this amount could be announced and all offered acres accepted. Since landowners willing to sell at this price will have an opportunity cost less than this price, total social welfare will be maximized—the price would be "socially efficient". In contrast, auctions that try to limit procurement costs might deviate from social welfare maximization by rejecting some low-cost sellers in order to motivate competitive bidding by all participants.

While the above example of a socially efficient mechanism is simple (and assumes that all acres have the same erosion rates), other straightforward mechanisms are plausible. For example, Polasky et al. (2014) introduces a "subsidy" auction that incentivizes truth revealing bids, and achieves Pareto optimality under a variety of conditions (such as when geographic contiguity of parcels matters). However, these approaches require unusual institutional structures. For example, the "subsidy" auction rewards the entire value of the ecosystem service to the landowner—information rents completely absorb the social value of the conservation policy. A similar "tax" auction mechanism avoids these large information rents, but removes the voluntary nature of a conservation policy by requiring landowners to fully compensate for lost ecosystem services.

A different set of issues arise if program budgets are constrained, so that the Government is not capable of purchasing from all willing sellers at a socially efficient price. An auction mechanism that reduces procurement costs—by inducing bids closer to opportunity costs—can free up money to purchase more units. As illustrated in the Appendix A, the gain from purchasing extra units can justify the use of an expenditure reducing procurement mechanism in a world where social welfare maximization is important.

Thus, it is useful to consider alternative auction designs that are more cost-effective: that reduce the cost of achieving program goals, or that maximize benefits given a budget (or acreage) constraint. In particular, the existence of observable differences in seller's costs can be leveraged to achieve cost-effectiveness goals. If the buyer has some indication of which sellers have low costs and which have high costs, the buyer can adjust the auction scheme so that low cost sellers are induced to bid less than they otherwise would—without using bid caps.

Several possible strategies are of interest, both as practical alternatives and illustrative examples (Hellerstein et al., 2015a). One approach is to modify the ranking mechanism by imposing

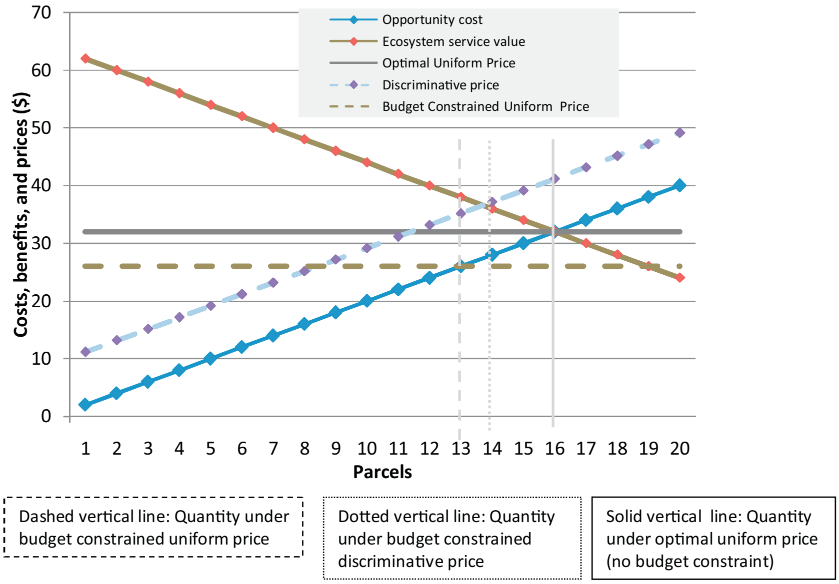

Fig. 7. Parcel retirement under alternative pricing schemes and budget constraints (using simulated data).

Table 3
Results from three budget and pricing scenarios.

Procurement mechanism	Acres retired	Total payments to retired acres	Conservation benefits from retired acres	Net profits from agriculture, from non-retired acres	Opportunity cost of retired acres	Total benefits
Using a socially optimum, uniform price of $32 (no budget constraint)	16	$512	$752	$148	$272	$900
Using a uniform price of $26, given a budget constraint of $338	13	$338	$650	$238	$182	$888
Using a discriminative auction, given a budget constraint of $338 (max payment is $37)	14	$338	$686	$210	$210	$896

Note: total benefits is the sum of “conservation” benefits from retired acres, and the value of production (the net profits from agriculture) from non-retired acres.

a penalty on offers submitted by sellers who are a priori identified as being low cost. These low-cost sellers would then face stiffer competition from otherwise uncompetitive higher-cost sellers (who are not penalized), and may respond by lowering their asking price (or proposing more beneficial conservation practices). For example, landowners from areas with lower average rental rates might have EBI points subtracted from their score; or offers from high-cost areas could have discounts applied to their asking prices when calculating the EBI score. Alternatively, a reference price auction would assign a non-binding value (a reference price) to each landowner; with the reference price based on a measure of the parcel’s value (say, using the parcel’s SRR). EBI points are added (subtracted) to bids below (above) their reference price. Landowners placing bids from lower-cost areas—who would have relatively low reference prices assigned to their parcels—would then have an incentive to boost their EBI scores by requesting rental rates that are not well-above their reference price.

Quota auctions (also known as set-aside auctions) offer another strategy (Cramton and Ayres, 1996; Milgrom, 2004) These involve imposing a quota, or limit on the number of offers, accepted from any group of offers having similar observed characteristics. For example, in a program like CRP, administrators might limit acceptances to 90 or 95 percent of all offers from any given county (or a set of similar counties). Without the limit, counties with especially low costs might have all their offers accepted. Landowners in these low-cost counties, recognizing their cost-advantage, could request rents that far exceed their costs. A limit on the share of offers accepted would force landowners in low cost counties to consider what their “neighbors” might request, which can induce greater competition (Roberts et al., 2014).

Recent experimental work (Hellerstein et al., 2015b,c) have examined these mechanisms with encouraging results. As with the experiments discussed above, in the quota and reference-price auctions participants could improve the “quality” of their offer as well as choose an asking price. The inclusion of costly changes to quality is meant to capture the choice of conservation practices faced by CRP participants: that mere enrollment in a program is not the whole story, that the benefit from conserving a given parcel can be enhanced. For example, rather than using an inexpensive grass cover to prevent erosion, a more wildlife friendly (but more costly) cover could both prevent erosion and improve wildlife habitat. Enrollment mechanisms that induce landowners to improve the environmental quality of land enrolled in conservation programs, even without overall reduction in government expenditures, may be of great interest.

Fig. 6 plots average "profit rates" computed across the experimental auction rounds, for 3 different mechanisms. A "non-contextual" design was used, where participants sold "tickets" to a single buyer. For each accepted "ticket", a profit rate is computed as its earnings (its bid minus its costs) divided by its costs. For each round, the average of these profit rates is computed. The charts display the distribution of these average profit rates. Note that a lower average profit rate suggests a more cost-effective auction design.

Regression analysis (summarized in Table 2) affirms the visual evidence in the plots. These alternative auction mechanisms can be more cost effective, both by reducing procurement costs and by encouraging more quality improvements.

5. The CRP enrollment mechanism: continuous signup

The continuous signup CRP was established in 1996, and now comprises over 25% of the CRP's acreage. Continuous signup differs from general signup in several ways:

- As implied by the name, land can be offered through continuous signup at anytime.
- Eligibility requirements for continuous are stricter than for general. Roughly speaking, continuous signup is meant to be used for acreage, and practices, that have high environmental benefits. For many practices, location matters: parcels will only be accepted if they are in targeted areas and have parcel-specific conservation covers installed.
- For example, conservation practices CP21, CP22, and CP29 provide "conservation buffers" (such as riparian buffers) and account for almost 0.8 million ha of continuous signup CRP. These parcels must be on lands that meet certain criteria (such as being adjacent to water bodies), and must be installed using recommendations provided by local experts (USDA NRCS, 2012).
- Acceptance into continuous signup is automatic—if a parcel is eligible for a continuous signup practice, and is offered into continuous signup, it is accepted.
- Payment rates start with the SRR for the parcel. In addition, for many practices this is increased by 20%. Furthermore, most practices qualify for "Signup Incentive Payments" (from 250 to $370 per ha) and "Practice Incentive Payments" (which can be 90% or more of installation costs) (USDA FSA, 2013b).

Essentially, lands (in combination with a desired conservation practice) eligible for continuous CRP are deemed to be highly worthy—in a sense, they are seen as lands that clearly should be retired from crop production, hence there is no need to subject them to the rigors of a competitive signup. As noted by a USDA/FSA CRP analyst:[1]

"CRP uses [a] classic adaptive management approach ... as a practice is demonstrated to be an effective tool for addressing a concern the program would be modified to address that concern."

The growth of continuous signup acres is a manifestation of this strategy, with many continuous practices starting out as general signup practices (often practices that provide a relatively high EBI scores) becoming eligible practices in continuous signup. For example, wetland practices were part of general signup until 2004, at which point they were moved to continuous signup. As the wetland acres in general signup expire, they often enroll into the same practice under continuous signup.

Continuous signup also includes several initiatives (USDA FSA, 2015b). These initiatives recognize certain concerns (such as "Duck Nesting Habitat"), proscribe a conservation practice, and announce an acreage goal. In a sense, the initiatives act as targeting and marketing tools for USDA—they provide a means of emphasizing the concern, so as to draw interest from potential participants.

Lastly, the Conservation Reserve Enhancement Program is a variant of continuous signup based on State—Federal cooperative agreements; with the State generally covering 20% of cost. There are approximately 45 projects spread over 33 states. These are often targeted to concerns of particular interest to the cooperating state. Additional financial incentives are often available.

Thus, continuous signup is an alternative to general signup. Where general signup uses an auction mechanism that incorporates bid caps, continuous depends on a form of explicit targeting—one that doesnot identify specific parcels a priori, but which does set relatively high eligibility standards.

How effective is this? On one hand, on parcels where a practice will provide important ecosystem services (such as wetland restoration), it is likely that enrollment of such a parcel will yield more benefits than the typical general signup acre. On the other hand, there is no competitive pressure on potential participants – they may receive more than their reservation prices – which may partially explain the substantially higher per acre rents paid in continuous signups. And, even though rental rates are higher, they still are capped – which may discourage some valuable parcels from being offered.

There is little research considering the effectiveness of continuous signup. One example is Khanna et al. (2003) who used a physical process model in a single Illinois watershed to examine the water quality protection contributions of CREP and general signup acreage, finding that as currently implemented CREP acres did not outperform CRP acres. Follow-up work (Khanna and Yang, 2011) expanded this analysis to several other watersheds, and found that CREP tended to be more effective at reducing nitrogen and sediment delivery to water bodies, but also often somewhat more costly. While far from definitive, these results suggest that the "targeting" approach of continuous may not always be best.

In addition to the lack of a competitive mechanism, continuous signup (by design) focuses on parcels that tend to do one thing very well. If the proportion of CRP in continuous signup increases, this is likely to lead to forgoing enrollment of acreage that does a number of things well, but nothing "very well"—the kind of acres that an EBI will identify.

6. Discussion and conclusions

The Conservation Reserve Program has been operating for over 25 years, and has undergone a number of transformations. Its enrollment mechanism started with an essentially open enrollment program aimed at highly erodible lands, and that imposed regional bid caps. Currently, most of the program's acreage is selected using a competitive discriminatory auction; one that ranks each offer using their environmental attributes and their bid, and that imposes a parcel-specific bid cap. A smaller, but growing, number of acres are obtained via a non-competitive but moderately stringent targeting mechanism.

Recently, the program has been shrinking in size—its legislated maximum size will shrink to 9.7 million hectares (24 million acres) in 2017. In the general signup, fewer parcels are being offered, while a higher percentage of offered parcels are being accepted. This may be explained by bid caps (the Soil Rental Rates) not rising as quickly as commodity prices (though with recent decreases in commodity prices, this effect may weaken). On the other hand, the program's acreage limit is also shrinking, perhaps reflecting legislative prioritization of production over conservation. Thus, decline in general signup offerings makes it institutionally easier to meet this declining acreage limit. However, this does mean a loss in conser-

[1] Personal communication, Skip Hyberg USDA/FSA; Washington DC (September 2014).

vation benefits of land retirement. Reductions in per acre costs, or increases in environmental benefits per acre (or per dollar expenditure) could counteract these trends. Thus, it is useful to consider improvements in the enrollment mechanism.

Given possible drawbacks to the current use of bid caps (the Soil Rental Rate) in general signup, we discuss and illustrate auction mechanisms that may be more cost effective. Alternatively, the ongoing growth in continuous signup can be seen as an alternative to the limitations of the general signup mechanism. While having the appeal of targeting acreage that are likely to have superior environmental benefits, as continuous signup grows it may not be as appropriate—there may be less "low hanging fruit". A question for future research is if the non-competitive (but bid capped) mechanism used in continuous signup may become less effective than an improved general signup mechanism.

This paper mentions, but does not discuss in detail, an important consideration: how accurate is the EBI in measuring benefits. In particular, if environmental benefits flow from a landscape, the ecosystem services provided by a given parcel depend on what is happening in its neighborhood. The EBI, and to a certain extent the decision as to what should be eligible for continuous signup, does not incorporate these kind of neighborhood effects. More generally, the EBI is rooted in an "expert opinion" process that may not take full advantage of available science, and rarely considers non-market valuation. The challenge of improving the EBI—so that it accurately measures the value of ecosystem services—is difficult, but is hard to substitute for no matter how clever one's enrollment mechanism may be.

Appendix A.

Economic Efficiency Under Limited Budgets

When conservation programs have a fixed budget that is not large enough to purchase the socially optimal quantity of ecosystem services, a procurement-cost reducing auction mechanism—by allowing the available budget to purchase a quantity closer to the social optimum—can yield social welfare outcomes that are superior to mechanisms that would be Pareto optimal in the absence of a budget constraint.

The following land retirement example illustrates this case. Assume that:

- Twenty 1-acre parcels that have opportunity costs (net profits from agricultural production) between \$2 and \$40.
- The parcels are environmentally the same (they provide identical ecosystem services), but the total benefit from all retired lands is decreasing: the first acre retired provides \$62 in environmental benefits, while the 20th acre retired provides \$24.
- The marginal benefit and cost curves are linear.

Fig. 7 shows costs and benefits, and the Table 3 displays results. The socially optimal price is \$32, with a total expenditure of \$512 and a total benefit of \$900 (the sum of conservation benefits from retired land + sum of net agricultural profits of non-retired land)

Suppose, however, that the Government is constrained to spending only \$338. If a simple market mechanism is used, only 13 acres can be retired at a uniform price of \$25. The imposition of this budget constraint drops the net social benefits from \$900 to \$888. In contrast, consider a discriminative auction (that pays selected offers their bid) with a bid cap always \$9.15 greater than the opportunity cost, and assume that all farmers make an offer equal to their bid cap. \$338 will allow 14 acres to be retired, yielding total benefits of \$896. Alternatively, retaining net benefits at \$888 (by retiring 13 acres) would cost \$301 under the discriminative auction (89 percent of the \$338 in expenditures under a simple market).

The discriminative pricing obtained through the auction mechanism reduces payments to low-cost sellers. These savings are then used to retire more acres, allowing the Government to purchase a number of acres closer to the optimum quantity. While this example's budget constraint (of \$338) and bid cap (that is always \$9.15 greater than the opportunity cost) were chosen for numerical simplicity, it does illustrate how auctions can yield better social welfare outcomes than simple market mechanisms.

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