Western Economics Forum

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The Western Economics Forum

A peer-reviewed publication from the Western Agricultural Economics Association

Purpose

One of the consequences of regional associations nationalizing their journals is that professional agricultural economists in each region have lost one of their best forums for exchanging ideas unique to their area of the country. The purpose of this publication is to provide a forum for western issues.

Audience

The target audience is professional agricultural economists with a Masters degree, Ph.D. or equivalent understanding of the field that are working on agricultural and resource economic, business or policy issues in the West.

Subject

This publication is specifically targeted at informing professionals in the West about issues, methods, data, or other content addressing the following objectives:

- Summarize knowledge about issues of interest to western professionals
- To convey ideas and analysis techniques to non-academic, professional economists working on agricultural or resource issues
- To demonstrate methods and applications that can be adapted across fields in economics
- To facilitate open debate on western issues

Structure and Distribution

The *Western Economics Forum* is a peer reviewed publication. It usually contains three to five articles per issue, with approximately 2,500 words each (maximum 3,000), and as much diversity as possible across the following areas:

- Farm/ranch management and production
- Marketing and agribusiness
- Natural resources and the environment
- Institutions and policy
- Regional and community development

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The Influence of the Pace and Scale of Energy Development on Communities: Lessons from the Natural Gas Drilling Boom in the Rocky Mountains

Michelle Haefele and Pete Morton[1]

Introduction

Both the number of oil and gas wells drilled annually[2] (U.S. Department of Interior [U.S.D.I.], Bureau of Land Management 2009) and the number of producing natural gas wells[3] (U.S. Department of Energy 2009) in the Rocky Mountain region[4] more than doubled from 1998 to 2008. The proportion of U.S. natural gas production from the region increased from 16% in 1997 to 23% in 2007 (U. S. Department of Energy 2009) and the number of drilling rigs operating in the region grew from 131 in 2002 to 318 in 2009.[5] This increase in natural gas drilling in the region has created boomtown conditions in several rural communities.

While energy development can benefit rural communities, boomtowns in the Rockies experienced an influx of non-local workers, a rise in crime and emergency service calls, increased demand for public services, more wear and tear on local infrastructure, and upward pressure on local wages and housing costs. Natural gas prices had dropped dramatically by 2009, the drilling boom had subsided, and the bust phase may have begun (Figure 1). The recent energy boom-bust begs the question—how can communities learn from recent history to better take advantage of future energy development for both short-term and long-term benefits?

[1] The authors are Economist and Director of Economics, respectively, The Wilderness Society, Denver, Colorado.
We would like to thank Dr. Joe Kerkvliet for his insightful reviews of earlier drafts. The paper has also benefited greatly from the eagle-eyed editing of Ms. Barbara Young. Thank you both.
We would also like to thank the anonymous reviewers whose very helpful comments and suggestions have improved and shaped this paper greatly.
[2] On public lands and on split-estate lands (where the surface is privately owned, but the resources beneath are publically owned).
[3] On all lands, public, private and split-estate.
[4] Colorado, Montana, New Mexico, Utah and Wyoming.
[5] Baker-Hughes Rig Counts http://investor.shareholder.com/bhi.

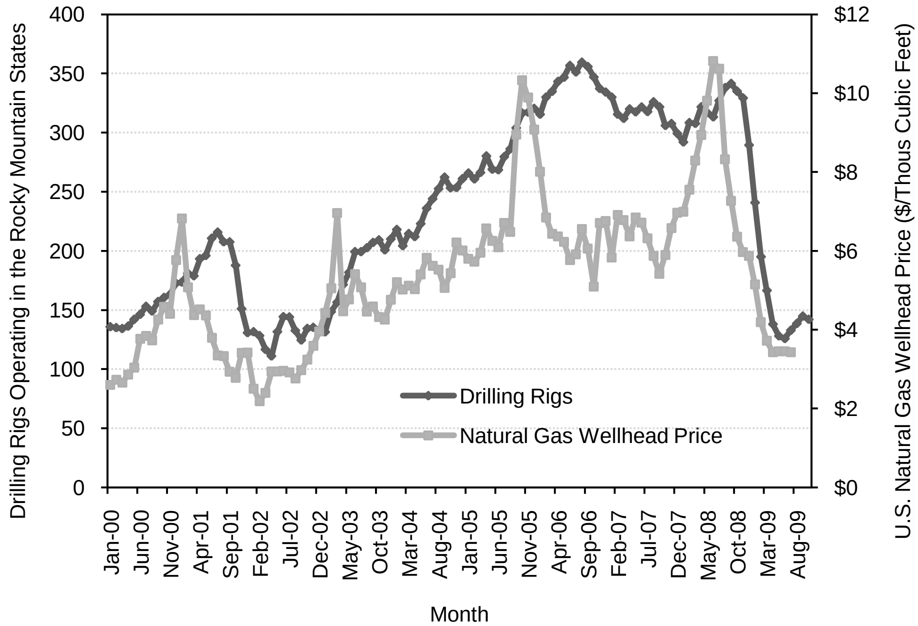

Figure 1. Monthly Drilling Rig Count for the Rocky Mountain Region and U.S. Natural Gas Wellhead Prices

Note: throughout the period shown the total rig count for the U.S. ranged from 750 to 2000.

Sources: rig counts: Baker-Hughes Rig Counts http://investor.shareholder.com/bhi/; natural gas prices: U.S. Department of Energy, Energy Information Administration (http://www.eia.doe.gov/).

This question is explored with a short literature review, followed by recent case studies of Western boomtowns, and ending with a recommendation as per the pace and scale of development to reduce the economic costs while deriving the benefits of energy development.

Background

Past research indicates that an emphasis on resource extraction (logging, oil and gas, mining) often results in economically unstable communities (Fortmann et al. 1989; Freudenburg 1992; Freudenburg and Gramling 1994). Gulliford (1989) recounts the economic hardship and social turmoil of the oil shale boom-bust cycle in Colorado twenty-five years ago. Smith (1986) suggests the oil and gas industry is more prone to boom-bust cycles than mining. This finding is echoed by Slack and Jensen (2004) who find chronic underemployment to be more of an issue with oil and gas than with mining. Brabant and Gramling (1997) note the problem of persistent poverty in extractive industry-dominated economies. However, Flint and Luloff (2005) suggest that resource-dependent communities possess adequate social capital (described by Putnam (1995) as a society's connections and shared values) and community structure to protect themselves from the inherent risks associated with natural resource industries.

Increased economic diversity can mitigate the inherent risks from resource dependency because when one industry experiences a downturn, a larger variety of industries will be more able to absorb the unemployed. Conversely, areas dominated by one industry often lack this capacity (Wagner and Deller 1998; Malizia and Ke 1993). Malizia and Ke (1993) find that greater economic diversity predicts lower unemployment rates and greater employment stability, and that areas with high concentrations of employment in unstable industries have higher overall unemployment rates. Headwaters Economics (2008a) finds that most energy-focusing counties have slower economic growth than other counties in the West. Wagner (2000) notes that pursuit of a growing industry is an appropriate short-term strategy for economic growth, but is best coupled with policies designed to increase economic diversity to provide long-term stability. Neumann and Topel's (1991) findings are less conclusive, although they do note that unemployment is lower in markets with greater labor mobility among industries.

The Role of Pace and Scale in Boom-Bust Cycles

Two inherent characteristics of booming times are the rapid pace and large scale of development. A "boom" is defined as "a rapid widespread expansion of economic activity" (Merriam-Webster 1990). "Pace" indicates the speed with which an area is developed – in many instances a large number of wells are drilled in a very short time. "Scale" indicates the geographic or spatial extent of development – the recent drilling boom has spread across a large geographic area. Pace and scale are often interrelated; in many cases, as the pace is slowed, the spatial extent of development will decline. Large scale booms extend drilling into marginal areas which tend to be abandoned when prices drop; areas with the largest rate of growth experience the largest rate of decline (Smith 1986).

Booms often exert upward pressure on wages, creating labor challenges for local governments and non-energy-related businesses (Headwaters Economics 2008c; BBC Research and Consulting 2008a, b). Social problems develop from a sudden influx of workers migrating into the area during "boom" times (Merrifield 1984; Davenport and Davenport 1980) including the sense of dissatisfaction arising from rapid change (Smith et. al 2001; Brown et al. 2005; Goldsmith 1992; Gulliford 1989; Merrifield 1984; Kittredge 1987; Kelly 1980). Drilling booms increase housing demand which raises prices, leading to increased poverty among those unable to take advantage of new jobs (Brabant and Gramling 1997). Local governments need to provide basic services for a rapidly growing population, along with increased per capita service demand, resulting in fiscal burdens for taxpayers (Merrifield 1984; Headwaters Economics 2008c; BBC Research and Consulting 2008a, b).

Recent Case Studies from the Rockies

Headwaters Economics (2008b) finds that five percent of the counties in the West experienced a surge in energy development, particularly in northwest Colorado and southern Wyoming. These areas were subjects of detailed economic studies and serve as useful case studies.

1. Colorado Case Studies:

BBC Research and Consulting (2008a) examined four northwest Colorado counties (Mesa, Garfield, Rio Blanco and Moffat) experiencing fast-paced energy development. This region of Colorado suffered the consequences of boom-bust oil shale development in the late 1970s and early 1980s. When the industry abruptly stopped work on May 2, 1982 ("Black Sunday"), the region entered a brief economic downturn, but has since experienced growth due in part to a diversified economy.[6] In 2006, energy and natural resources accounted for 11.6% of basic jobs.

[6] For example, the community of Battlement Mesa, built to house oil shale workers, evolved into a thriving retirement community.

Tourism jobs accounted for 16.7% of total personal income and non-labor income[7] accounted for 28.6%. The BBC study notes oil and gas workers are mostly temporary, non-local employees who occupy between fifteen and thirty percent of the area's motel rooms. The increase in energy industry employment is predicted to put upward pressure on wages, along with creating a lag in projected non-energy businesses growth.

The BBC study (2008a) also examines the fiscal effects of energy development on local governments. Costs associated with energy development, over and above those expected with normal economic and population growth, include additional wear and tear on roads and additional costs from expanding government services. The authors predict the region will face substantial budget shortfalls if energy development continues to escalate. Compounding the budget problem is the fact that most of the expenditures occur early in the boom, while revenues are received in later years.

A related study (BBC 2008b) focusing on Rifle, Colorado (in Garfield County) (the community most hurt by the 1982 bust in oil shale development) found that the fiscal costs of increased energy activity far outweighed revenues. Rifle has experienced considerable growth in recent years. Despite a historic reliance on resource extraction, the economy has benefited from diversification in the last quarter-century. The report found that the drilling boom has "crowded out" new businesses, creating the possibility that economic diversity may decline or cease to grow.

Rapid energy development in the Rifle area has resulted in a two-fold infrastructure funding problem. First, Colorado state law does not guarantee that oil and gas revenues will flow to impacted communities. Second, there is an estimated delay of three to eight years between peak expenditures and peak revenues.

A third Colorado study examined the role of energy in the state's economy, taxes on the fossil fuel extraction industry, and the impacts of the recent energy boom on other industries (Headwaters Economics 2008c). This report finds that energy development increases the need for public investments in infrastructure, and that current tax policies do not address the added costs. Headwaters (2008c) also finds that Colorado counties with more employment in mining experienced lower overall income growth.

Prior to the boom, Mesa and Garfield Counties were affordable alternatives for retirees and workers in nearby resort communities (Headwaters 2008c). The influx of workers during the drilling boom increased demand for housing in an already strained market, resulting in higher housing costs. Residents not tied to energy jobs are less able to afford the increased costs and may have to move. Labor demand in the energy sector also created upward pressure on wages in all sectors. During the boom the government sector (the largest employer) was challenged to increase wages, and school districts and hospitals had difficulty filling positions. The authors note that local motels are often filled by temporary energy workers. Labor shortages during the drilling boom delayed housing projects, adding to the housing supply shortfall and exacerbating the problem of housing affordability.

Finally, Headwaters (2008c) notes a shift in area demographics. Retirees who had been the "pioneers" after the post oil shale bust are now leaving the area, often due to changes brought

[7] Non- labor income is not tied to a job. This include retirement payments, transfer payments and investment income.

about by the recent boom. High-paying energy jobs may be responsible for an observed decline in the number of high school graduates attending college. These changes increase concerns that the mix of industries will narrow once again to focus primarily on energy, threatening long-term economic diversity.

2. Wyoming Case Study:
Sublette County, Wyoming provides another example of boomtown impacts from rapid energy development, especially in the Jonah Field. The 1998 Environmental Impact Statement projected community impacts assuming that 400 wells would be drilled over 20 years (U.S.D.I., Bureau of Land Management 1998). However, 400 wells were drilled within the first three years of development, and a subsequent Infill Plan was approved allowing 3,100 additional wells to be drilled (U.S.D.I., Bureau of Land Management 2006).

Ecosystem Research Group (2007) concludes that the county economic base changed from agriculture to oil and gas extraction in the past decade; the county produced 44% of Wyoming's natural gas in 2006,. Taylor and Foulke (2008) note declining employment diversity in Sublette County, most likely due to increased employment in natural gas drilling and construction (which is linked to drilling). Between 2000 and 2006, energy development was responsible for a 24 % increase in population (nearly four times the national rate), although in a narrow 20 to 34 age range (Taylor and Foulke 2008). Taylor and Foulke (2008) found that, compared with past booms, more workers commute from outside Sublette County and that enrollment growth in County schools did not correspond with employment growth, implying that the workforce associated with the recent natural gas boom is more transient than in past booms.

During the same time period, average home price increased at twice the state rate, making the county unaffordable for the average wage-earner (ERG 2007). Rental costs increased 90% to reach a level 60% higher than the rest of the state. A large wage gap exists between natural gas workers and those in other sectors, meaning the rental cost increase falls disproportionately on non-energy workers. While county revenues increased, the cost of providing public services also increased (Taylor and Foulke 2008; ERG 2007; Pinedale Anticline Working Group 2005).

Oil and gas work is often dangerous (Loomis et al. 2007). The National Institute for Occupational Safety and Health (2009) finds the rate of worker fatalities is positively correlated with the pace of drilling, attributing the increase to inexperienced workers. Emergency medical service calls also increase with drilling (ERG 2007; Pinedale Anticline Working Group 2005). Jacquet (2005) demonstrates a link between per capita emergency service calls and increased gas drilling in Sublette County. ERG (2007) also shows steadily increasing numbers of ambulance (EMS) runs in Sublette County between 2000 and 2006.

Rapid development has reduced employment diversity in Sublette County, Wyoming (Taylor and Foulke 2008) and Garfield County, Colorado (Table 1) where the proportion of total employment in mining has rapidly increased, implying some loss of employment diversity.

Table 1. Percentage Of County Employment in the Mining Sector

	2000	2001	2002	2003	2004	2005	2006
Sublette County, WY	8.2%	10.2%	10.7%	13.8%	14.6%	14.9%	17.6%
Garfield County, CO	1.0%	1.3%	1.6%	2.4%	3.1%	4.9%	6.2%

Source: Regional Economic Information System, Bureau of Economic Analysis, U.S. Department of Commerce

News accounts document the social issues from the recent boom. In some cases residents are leaving due to reduced quality of life and property values.[8] There are accounts of damage to rural roads,[9] poaching of wildlife,[10] and other crime, especially drug use.[11] Jacquet (2005) found a correlation between incidents of serious felonies and arrests and increased gas drilling in Sublette County.

Controlling the Pace and Scale of Oil and Gas Development

Many of the problems associated with the recent drilling boom in the Rockies are either caused by or exacerbated by the large scale and rapid pace of development. Slowing the pace and scale of development can reduce these problems by reducing the number of wells drilled at one time. Assume, for example, that 2,500 producing wells are needed to extract the resources. Figure 2 shows the total number of wells that would be drilled each year and total producing wells operating annually under several pace-of-development scenarios. Slowing the pace and spreading drilling over years or even decades means there will be producing wells in the area for a longer time period, but the dramatic peak in the earlier years will be diminished. The most rapid pace of development occurs in a very brief period where the drilling would be intense – resulting in boomtown conditions.

[8] "Silt couple selling 110-acre ranch," The Grand Junction Daily Sentinel, 26 February 2007.
[9] "Boom hits county roads," Casper Star-Tribune, 13 December 2006.
[10] "Poachers making a killing in West's oil, gas fields," USA Today, 15 February 2007.
[11] "Boomtown Blues," The New Yorker, 5 February 2007.

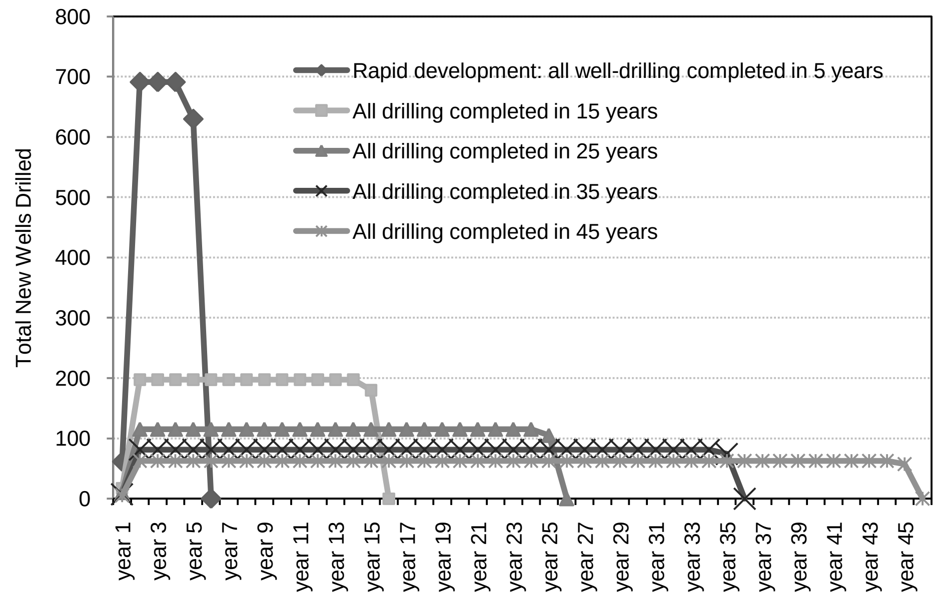

Figure 2a. Estimated Annual Well Drilling Under Five Pace-of-Development Scenarios

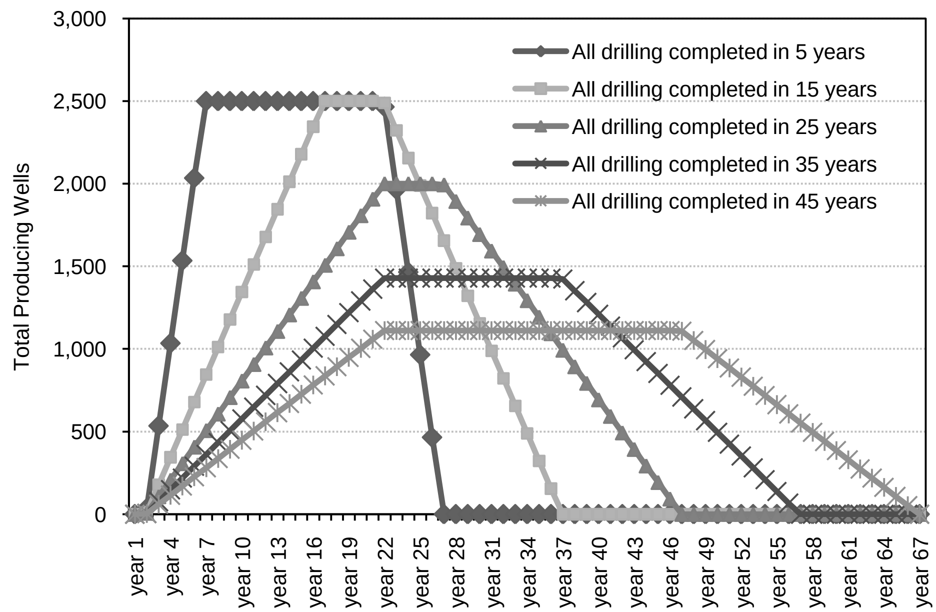

Figure 2b. Estimated Annual Total Producing Wells Under Five Pace-of-Development Scenarios

In-migrating energy workers are at the root of most of the socioeconomic problems. The drilling phase of natural gas development generally results in higher labor demand than the production phase. Slowing the pace and spreading drilling over a longer time will alter the patterns of industry employment (Figure 3). Using a ratio of 6 drilling jobs to 1 production job, the employment effect of various pace-of-development scenarios is provided. The shorter the drilling period, the more pronounced the "peak" in employment.[12] It is this peak in labor demand that creates many of the boomtown impacts. Slowing the pace of development results in fewer energy-related jobs initially but employment continues over a longer period.

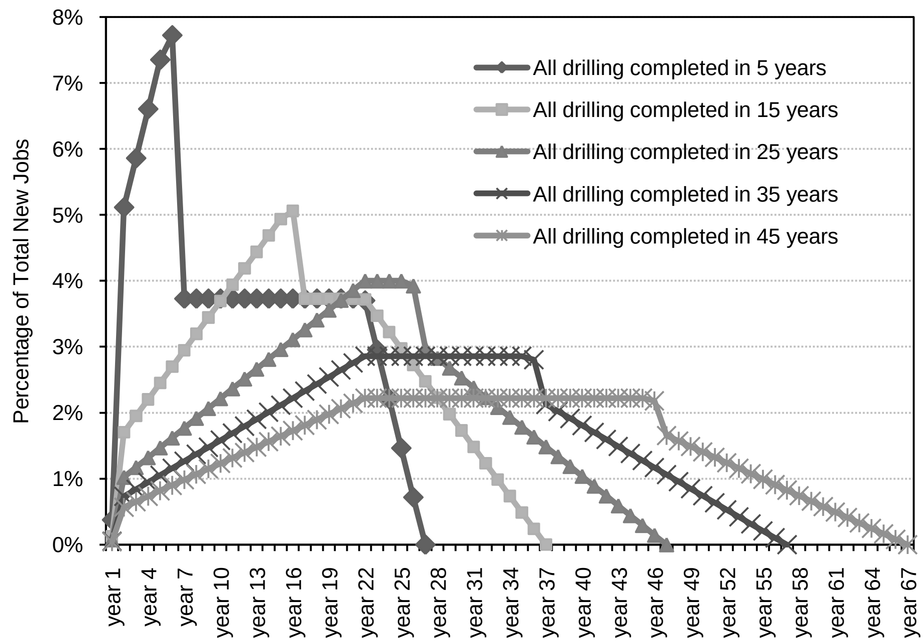

Figure 3. Estimated Annual Percentage of Total New Employment Under Five Pace-of-Development Scenarios

Slowing the pace and thereby reducing the scale of development will reduce the number of workers migrating into an area and mitigate the associated negative socioeconomic impacts.

Discussion and Conclusions

Certainly, communities can benefit from oil and gas development, but the total costs must also be counted, including social dissatisfaction from rapid demographic and lifestyle changes. Smith et al. (2001) and Brown et al. (2005) found that in time communities recover from this dissatisfaction; however, it is reasonable to believe that residents would prefer to avoid the period of discontent. Flint and Luloff (2005) note that social capital is important for community resilience; slowing the pace and reducing the scale of energy development may facilitate the ability of communities to sustain social capital.

Rapid paced, large scale energy development often results in added costs to local governments to meet the needs of an influx of workers which accrue well in advance of energy-related revenue (Merrifield 1984; BBC Research and Consulting 2008a, 2008b). Merrifield proposes

[12] We assume that the same total number of wells will be drilled regardless of the rate of development, and that therefore the same number of jobs will accrue.

several (often complicated) solutions; however, simply slowing the pace and reducing the scale of development may reduce or even eliminate the need for public investment.

Another reason to slow the pace and scale of development is to help protect a region's natural amenities (such as open space, scenic vistas, recreation opportunities, clean air and water) that many economists believe play an important role in promoting economic diversity (Rudzitis and Johansen 1989; Whitelaw and Neimi 1989; Johnson and Rasker 1993, 1995; Rasker 1994; Power 1995, 1996; Snepenger et al. 1995; Bennett and McBeth 1998; Duffy-Deno 1998; McGranahan 1999; Nelson 1999; Rudzitis 1999; Lorah 2000; Deller et al. 2001; Johnson 2001; Shumway and Otterstrom 2001; Lorah and Southwick 2003; Low 2004; Holmes and Hecox 2004; Rasker et al. 2004; Kwang-Koo et al. 2005). Oil and gas drilling has the potential to suppress amenity-driven growth (Morton et al. 2004; Headwaters Economics 2008c; BBC Research and Consulting 2008b) by altering the flow of goods and services produced by the pre development landscape.

Much of the oil and gas development is taking place on public lands administered by the U.S.D.I. Bureau of Land Management (BLM). The agency can help communities gain control over the pace and scale of this development by requiring phased leasing or phased development – incrementally opening an area for development, limiting the total area developed, or limiting the percent of the area developed at any one time will reduce both the pace and scale of development.

Controlling the pace and scale of natural resource development is not a new concept. American foresters dating back over 100 years to Gifford Pinchot who recommended controlling the pace and scale of logging in order to "regulate" the forest and sustain the level of timber harvest in perpetuity (Sample 2004). If 200 acres of forestlands are managed on a 100 year rotation, an average annual harvest of 2 acres would occur for that period. Phased energy development simply applies this long-standing "regulated" forest concept to oil and natural gas by controlling the pace and scale of drilling.

Further research is needed to assess the net fiscal impacts of slower energy development. Slowing the pace of energy development may not maximize profits or gross tax revenues, but slowing development can reduce fiscal costs, which serves to increase net revenues to communities and states. Slowing the pace of development can help land management agencies control monitoring and enforcement costs so that they do not exceed the available budgets.

Decreased fiscal costs, reduced environmental damages, enhanced economic diversity and increased stability for Western communities can be achieved by ensuring local economies a more stable long-term energy industry and avoiding the boom-bust cycles of rapid paced, large scale energy development.

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Can Carbon Find a Home on the Range?

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As concerns over global climate change increase, there is growing interest in the potential for agricultural lands to provide ecosystem services related to carbon sequestration. Many geologic sequestration techniques remain unproven and cost prohibitive; yet, terrestrial sequestration is currently viable, both economically and environmentally (De Steigur et al. 2008). Rangelands are a major land cover in the United States, and particularly the West, accounting for nearly half of the 336 million hectares (Mha) of grazing lands in the U.S. (Schuman et al. 2002). They have received less attention in the literature as potential carbon sinks when compared to forest and crop lands. While the per acre carbon capture potential of rangelands may be less than either crop or forest lands, the scale of rangelands in the U. S. and globally suggests that total carbon sequestration on these lands can impact carbon cycles.

The Chicago Climate Exchange (CCX) has recently initiated a program allowing the trading of carbon credits[14] sequestered in rangeland soils (CCX 2009). Participation in the CCX exchange is currently voluntary, with the specific goal to reduce emissions of greenhouse gases in North America via offset programs (CCX 2009). Due to the voluntary nature of the program, carbon prices have varied greatly, experiencing a drastic drop in response to the current economic situation. As producers have entered the CCX program, uncertainties have arisen about the true costs and benefits of this program. Moreover, further complications have arisen from uncertainty about how agricultural credits will be handled by proposed cap and trade legislation. Agricultural economists must develop a better understanding of how rangeland carbon cycles are impacted by adoption of management practices. It is equally important that the incentives which would motivate producers to participate in these management practices are fully understood. This understanding will help policy makers evaluate the potential effectiveness of alternative carbon sequestration policies on rangelands ex ante.

The State of Knowledge Regarding Carbon Sequestration on Rangelands

Grazing lands occupy 37% of the total land area, or 336 million hectares (Mha), in the US, and represent about 15%[15] of the potential for US soils to sequester carbon (C) (Lal et al. 2003). Grazing lands are typically characterized by short periods of high C uptake and long periods of C balance or small losses (Svejcar et al. 2008). These types of relationships must be accounted for in any long-term economic modeling efforts.

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[14] A credit is measured as a metric ton of carbon.

[15] Lal et al. (2003) base this on grazing lands in the US having the potential to sequester Carbon in the range of 13-70 teragrams (Tg) of carbon per year, mean=42.

Rangeland soil organic carbon (SOC) sequestration rates have been estimated between 0.07 to 0.30 megagrams (Mg) C per hectare per year (Derner and Schuman 2007). Rangelands play an important role in the global C cycle. The large reservoir of sequestered C can be lost from the ecosystem with improper management; yet high rates of SOC accumulation can be attained by improving degraded rangelands. Therefore, a significant store of soil C in carbonate form in semi-arid and arid environments can act as both a sink and a source of C (Follett et al. 2001; Svejcar et al. 2008). The magnitude of soil C sequestration in rangelands depends the following: climatic trends (Derner et al. 2006), plant community (Conant et al. 2001), land management (including grazing, burning, and ecological restoration) (Follett et al. 2001) and disturbances such as recurring drought, nitrogen deposition, and climate variability (Jones and Donnelly 2004; Ingram et al. 2008; Svejcar et al. 2008).

Gaps in scientific knowledge on soil C sequestration in grazing lands are more numerous and prevalent than in crop and forest lands (Derner and Schuman 2007). However, the main considerations in SOC sequestration for grazing lands include the following: 1) in contrast to forests, the aboveground C pool is <5% of total C storage and mean residence time of the aboveground pool is only 1 to 2 years; 2) most SOC is recalcitrant, well-protected from natural disturbances, and generally resists change; 3) major pathways of SOC input are through decomposition of below-ground root biomass, surface deposition of animal feces and decaying litter from above-ground forage; and 4) large perturbations in the SOC pool occur with soil disturbances, such as through wind and water erosion following natural (e.g., extreme weather) or human-induced degradation (Follett et al. 2001). Three main drivers that control the fate of C on grazing lands are as follows: 1) long-term changes in production and quality of above- and below-ground biomass; 2) long-term changes in the global environment such as rising temperatures, altered precipitation patterns and rising CO_2 concentrations that affect plant community composition and forage quality; and 3) effects of short-term weather conditions (e.g. droughts) on net C exchange (Ciais et al. 2005; Soussana and Lüschert 2007; Ingram et al. 2008; Svejcar et al. 2008).

The best management practices (BMP) for sequestering C on croplands and the related economic consequences of those practices have been the subject of a growing research literature (see for example, Antle et al. 2002a; Antle et al. 2002b; Antle et al. 2001a; Antle et al. 2001b). Relatively little research exists related to rangeland C sequestration. Research suggests there are several management practices that can improve the amount of C sequestered on rangelands (Derner and Schuman 2007; Mortenson et al. 2004; Schuman et al. 2002). Campbell et al. (2004) investigate the costs of storing C on Wyoming rangelands by means of inter-seeding *falcata* alfalfa, better utilization of rangeland by implementing mineral or water placement, and sagebrush thinning on a central Wyoming ranch. Based on secondary data the authors conclude that Wyoming ranchers could potentially compete with crop and forest lands for sequestering C on a cost per unit basis. Schuman et al. (2001) suggest that the adoption of BMP such as proper stocking rates, adaptive management and destocking during drought conditions on poorly managed rangelands (113 Mha), could result in sequestration of 11 Tg C per year. Continuation of these BMP on the remaining rangelands would avoid losses of 43 Tg C per year. Many rangelands are nitrogen (N) deficient. N additions, through interseeding of legumes, can increase both forage production and C sequestration (Mortenson et al. 2004, 2005). Additional research is needed to determine how introduction of perennial legumes affects C and N cycling in rangelands. N additions in labile, legume-based organic materials may increase turnover rates and help mineralize stored SOC (Wedin and Tilman 1996). Soil organic C sequestration rates decrease with longevity of the management practice

(Derner and Schuman 2007), indicating that ecosystems reach a ‘steady-state.’ Additional changes in inputs would be required to sequester additional C (Conant et al. 2001, 2003; Swift 2001).

Relevant Issues for Economic Analyses of Carbon Sequestration on Rangelands

The above literature suggests the need for economic analyses of alternative management practices. The heterogeneity of rangelands offers a further research challenge. Actual rates of sequestration are likely to vary, complicating any land-scale modeling efforts aimed at estimating potential carbon storage. The CCX program treats rates of carbon sequestration as fixed across large eco-regions as long as stocking is ‘moderate’. There is little evidence that the CCX estimates of sequestration potential provide accurate information about actual storage potential, especially across various management practices.

Some range livestock producers in Wyoming and the West have enrolled in the CCX program while others have expressed potential interest in enrollment. The CCX requires a minimum of 10,000 tons of CO_2 in order to register to trade credits in the market, requiring most producers to use an aggregator in order to trade. Aggregators act as market intermediaries to pool credits from many producers to deliver the minimum amount required for participation. The services of the aggregator require payment (usually 8-10% of the value of credits they sell) creating additional costs to producers contemplating program enrollment. Enrollees in the program are responsible for paying registration and trading fees ($0.15 and $0.05 per credit respectively) as well as verification fees (between $0.10 and $0.12 per credit) (Ribera et al. 2009).

The CCX requires a 5-year contract to be allowed to sell carbon credits. If a producer discontinues the practices required for enrollment, they are required to re-pay previously earned credits. Producers must also have a grazing management plan, including a drought contingency plan, and must register each pasture with a Farm Service Agency (FSA) number separately (Agragate 2009).

There has been little research to date showing how costs of enrollment and compliance compare to the stream of revenues received from selling credits in the current CCX Rangeland Soil Carbon Offset program. Such information would help producers determine whether the program provides sufficient incentives to adopt the practices necessary to meet program requirements. Current net per acre payment levels may not be very attractive to local producers. Current per acre sequestration rates under the CCX program range from as low as 0.12 credits per acre in the Northwestern Wheat and Range Region, Rocky Mountain Range and Forest Region and Northern Great Plains Spring Wheat Region to as high as 0.27 credits per acre in the Western Great Plains Range and Irrigated Region[16]. The highest carbon prices received to date has been $7.40 per credit in August 2008, which translates to per acre payments ranging from $0.68 to $1.64 across the differing regions. However, since 2003, the average price of carbon has been only $2.47 per credit, and this price translates to per acre payments of only $0.14 to $0.45 across the differing regions.[17] If cap and trade legislation is

[16] These credit rats are based on rangeland in a “Non-Degraded” state per CCX regulations (CCX 2009). Map of Land Resource Regions is available at:
http://www.chicagoclimateexchange.com/docs/offsets/CCX_Rangeland_Soil_Carbon.pdf.

[17] Closing carbon credit prices are available at http://www.chicagoclimatex.com/market/data/summary.jsf. Per acre payments were calculated by the authors based on representative contract fees and costs from Agragate (2009) including a 10% aggregator fee, $0.10 per acre verification fee, and $0.20 per credit CCX trading cost.

enacted, the increase in carbon prices could raise payment levels to $8 to $11 per acre on rangelands (Ribera et al. 2009), which may make program enrollment more attractive to producers.

Ranchers are faced with the opportunity of adding a carbon credit enterprise to their existing operations. It is important operators understand how this new enterprise will impact the existing livestock enterprise. Some proposed management practices, such as reduced stocking rates, would likely have a direct impact on the livestock enterprise; however, other management practices, such as legume seeding, could create a positive externality for the livestock enterprise. Knowledge regarding these interactions, and the impact on profitability of alternative management practices, will be important for producers evaluating program participation.

If policy makers want to encourage sequestration on rangelands then it will be important to understand producers' attitudes toward carbon sequestration and alternative management practices. Relatively little research related to preferences of agricultural landowners to provide carbon sequestration as an ecosystem service has been published. Stavins (1999) used a revealed preference model of land use change to indicate costs associated with current policy instruments to sequester carbon are sensitive to land quality. Lubowski et al. (2006) used a similar approach to conclude policies impacting forestation or deforestation need to be evaluated in regards to sensitivity of total sequestration. Shaikh et al. (2007) survey agricultural landowners in western Canada regarding preferences for participating in a tree-planting program. They elicit willingness to accept (WTA) values from a discrete choice random utility model regarding compensation for landowners associated with tree planting compared to the resulting carbon sequestration benefits. They conclude that estimates of WTA are less than forgone returns from agricultural activities, but that the average costs of creating carbon credits exceed their projected value under the CO_2 trading scheme. Olenick et al. (2005) conducted a survey of western Texas landowners to investigate perceptions related to provision of ecosystem services from rangelands and found that respondents disapproved of programs that would encourage the proliferation of woody plants in an attempt to increase carbon sequestration. While these publications offer some insights into producers' preferences regarding carbon sequestration, more research targeted at rangeland production systems and alternative management practices would be beneficial.

Discussion

Research on the economic implications of rangeland carbon sequestration is in its infancy. There is much that economists can contribute to decision making for both landowners and policy makers. Modeling efforts that incorporate the long-term dynamic nature of the carbon cycle to capture the costs and benefits of engaging in carbon sequestering activities will help policy makers and landowners. These costs and benefits must include both the direct costs associated with program enrollment and the induced costs and benefits associated with changes in linked enterprises such as livestock production activities. Analyses should address policy impacts on individual producers as well as the potential for large-scale land-use changes. This will require knowledge of producer preferences for management practice adoption, individual benefits and costs, and the incorporation of contract and or price risk. While the state of knowledge regarding actual sequestration rates on rangelands is currently limited, economists can play a crucial role in leading multi-disciplinary research focused on management practices that show potential for producer adoption. Results from these types of research efforts will be helpful to both land managers and policy makers when evaluating whether carbon can find a "home on the range."

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Incentives for Spatially Coordinated Land Conservation: A Conditional Agglomeration Bonus

Cyrus A. Grout[18]

Introduction

Land conservation is a tool extensively used by governments and environmental organizations to obtain a multitude of environmental benefits. The largest land conservation program in the U.S. is the USDA's Conservation Reserve Program (CRP). It pays farmers to retire land in crop production in favor of conservation measures that will achieve environmental objectives such as reducing soil erosion, improving air and water quality, and providing wildlife habitat. Over 33 million acres were enrolled in CRP programs as of September of 2009. The efficient allocation of funds is a subject of interest to economists in that annual expenditures for land conservation range in the billions of dollars. An extensive economic literature has emerged analyzing the cost-effectiveness of conservation programs in achieving environmental objectives. See Claassen et al. (2008) for a review of U.S. conservation programs and previous research.

The marginal benefit of a conservation effort is often small until some threshold level of conservation has been reached. For example, the population of a species may not be viable when contiguous habitat is below some minimum acreage H_T. Conservation efforts resulting in the creation contiguous habitat of a size below H_T would provide no environmental benefits in terms of improving the viability of the species (see Figure 1).

Examples of such "threshold effects" considered in the economic literature include the effect of habitat fragmentation on bird and mammal species (Lewis and Plantinga, 2007; Parkhurst and Shogren, 2007; Parkhurst et al., 2002), and the effect of water quality on fish populations (Wu, et al., 2000). The marginal benefit of conserving a parcel of land may depend not only upon the parcel's characteristics, but on the spatial pattern of conservation among neighboring parcels given the presence of threshold effects. The concern is that ignoring threshold effects will result in an allocation of conservation funding that is spatially overly dispersed, as demonstrated by Wu and Boggess (1999).

Wu et al. (2000) consider a conservation issue prominent in the western United States: habitat enhancement for steelhead trout, a salmonid fish species. The authors identify a threshold effect in water temperature's impact on the steelhead abundance in the John Day River fishery in eastern Oregon: stream temperatures should not exceed 18° C. Measures that lower stream temperature one or two degrees when stream temperature is above 20° C have little effect on steelhead abundance. The authors find that the equal allocation of funds across sub-basins to improve stream habitat would tend to be inefficient because marginal benefits vary significantly depending on the condition of surrounding habitat. In the extreme case, benefits might even be zero if the allocation to each sub-basin fails to reduce temperatures below the threshold level.

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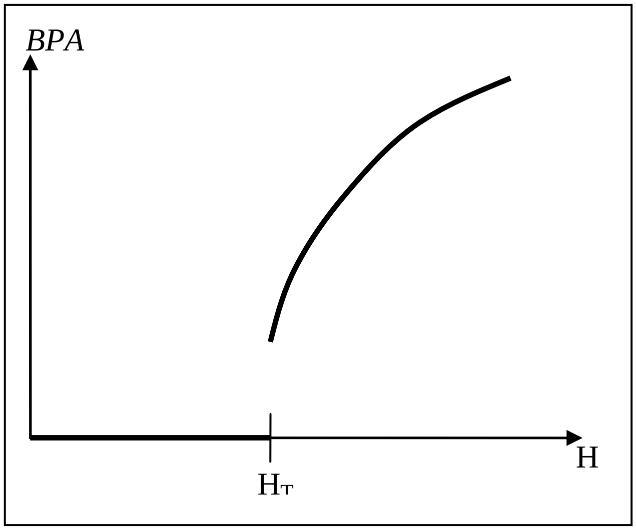
Figure 1. Benefit per Acre (BPA) of Contiguous Habitat Acreage (H)



An incentive mechanism proposed in the literature to encourage spatially coordinated conservation is the agglomeration bonus. It awards landowners bonus payments for the conservation of adjacent portions of land (Parkhurst and Shogren, 2008; Parkhurst and Shogren, 2007). In an experimental study, Parkhurst and Shogren (2007) found that groups of four players in a coordination game with an agglomeration bonus mechanism were able to achieve desired spatial configurations of land conservation (e.g., a wildlife corridor or core habitat) with over 90% efficiency. While these experimental results are encouraging, they were limited to the context of conserving endangered species habitat that overlapped several parcels of land. Furthermore, each player had exact knowledge of the other players' opportunity costs, and the total incentives paid to conserved land were disproportionately large.[19]

Real-world applications of the agglomeration bonus are rare. One is Oregon's Conservation Reserve Enhancement Program (CREP), established in 1998 with the goal of assisting the recovery of salmon and trout species by creating riparian buffers along stream habitat. The program includes a provision that awards a one-time "Cumulative Impact Incentive Bonus" (CIIB) wherever at least 50 percent of any 5 mile section of streambed is enrolled in the CREP (USDA 1998). In a 1998 survey of potential CREP participants, approximately 76% indicated a willingness to work with neighbors toward enrolling contiguous stream miles (Kingsbury, 1999). One reason cited by landowners for not wishing to take advantage of the bonus program was the perception that it would require a large investment in time to coordinate with neighbors. During the past decade CIIB awards in Oregon have not been extensive. However, the incentive has proven successful in encouraging CREP participants who have enrolled without bonus compensation to promote the program to neighbors who can put them above the 50% threshold required for CIIB eligibility (Sundseth, 2009).

Incomplete information is a frequent impediment to the design of effective incentive mechanisms. Regarding the agglomeration bonus, its functionality is dependent on landowners' knowledge of their neighbors' willingness to participate in conservation. For example, consider

[19] In the 2007 study, incentives totaling $1,168 were paid to four players who conserved the desired configuration of core habitat, while the forgone rent (i.e. opportunity cost) on that portion of land totaled only $192. From a cost-benefit perspective, it would be preferable to simply make a take-it-or-leave-it offer of less than $1,168 for the desired core habitat.

a farmer for whom the bonus level of compensation (paid to contiguous conservation) exceeds rents from agriculture, and suppose his agricultural rents are higher than some base-level compensation (paid to non-contiguous conservation). His payoff from enrolling in the conservation program may be positive or negative depending on whether the pattern of his neighbors' enrollment is sufficient to warrant bonus compensation. Hence, the farmer's expected payoff is a function of each neighbor's probability of enrolling. The farmer takes on risk by enrolling because his payoff could be negative. If information about neighbors' willingness to participate is limited, he may forego participation even when he and his neighbors would mutually benefit from enrolling as a group.

The above example illustrates a significant limitation to the agglomeration bonus mechanism as it has been represented in the recent literature: the agreement to enroll is binding on both the landowner and regulator. The agglomeration bonus literature has not examined the potential for conditional agreements to overcome the informational requirements necessary to induce spatially coordinated land conservation. The real-world applicability of the agglomeration bonus has likely been constrained by its strong information requirements. The modification to the agglomeration bonus mechanism proposed in this paper improves its applicability by limiting landowners' information requirements to knowledge of their own opportunity costs and eliminating the need for landowners to coordinate their enrollment decisions.

Landowner Responses to Voluntary Incentives

Predicting a landowner's response to an incentive such as a subsidy from the USDA's Conservation Reserve Program can be complex. Underlying the landowner's decision to accept or reject such a subsidy is the quality (i.e. productivity) of his land, and by extension, the stream of rents he can earn from its highest and best use. Two factors that introduce complexity to predicting a landowner's response to an incentive are the long term commitment inherent to most conservation programs (the minimum CRP contract is 10 years) and the individual characteristics of the landowner.

A landowner's calculation of expected opportunity cost under a long-term commitment will incorporate his current rents as well as expectations of the levels and prices of future inputs and outputs. A group of landowners with similar parcels of land are likely to form variable expectations about the proceeding 10 to 15 years. A landowner's willingness to enroll in a conservation program is also likely to depend on his personal characteristics. Conservation payments provide a relatively predictable stream of rents compared to crop production and a landowner's calculation of expected opportunity cost depends on his risk profile.[20] Due to such human heterogeneity, a fragmented response to an incentive is possible even where land rents and characteristics exhibit little heterogeneity.

The agglomeration bonus attempts to overcome fragmented responses by creating a positive network externality among neighboring landowners (Parkhurst and Shogren, 2007). It requires each landowner to perform what can be a complex task: to incorporate expectations of neighbors' responses into his own enrollment decision. Each landowner's expected payoff from enrolling in a conservation program is a function of his expected opportunity cost and expectations about his neighbors' enrollment decisions (which are equally complex). For

[20] For example, Parks and Kramer (1995) found that older landowners were more likely to enroll land in the Wetlands Reserve Program.

reasons discussed in the above paragraph, predicting the response of any particular landowner to an incentive can be difficult even where land characteristics are observable.

Unless the agglomeration bonus is very large or small relative to opportunity costs, each landowner is likely to face some degree of uncertainty about his neighbors' willingness to enroll their lands. Where a large number of landowners are involved and/or communication among landowners is poor, the ability of an agglomeration bonus to induce coordinated land conservation is likely to be limited. The following section proposes a modification to the agglomeration bonus that eliminates the need for landowners to form expectations about others' willingness to enroll.

A Conditional Agglomeration Bonus

Asking landowners to predict neighbors' responses to an incentive is unnecessary when landowners' agreements to enroll are binding if and only if a desired pattern of enrollment is achieved (e.g., n contiguous acres). A conditional agglomeration bonus (CAB) program would pay compensation only where the desired pattern of enrollment occurs. As represented in Figure 2 below, a regulator would offer some level of compensation (S^{CAB}) to landowners and observe the spatial pattern conditional enrollment. Where the desired pattern of enrollment does not occur, the landowner is released from his obligation to enroll land and the regulator is released from his obligation to compensate the landowner. Assuming zero transaction costs, landowner i will conditionally enroll in the program whenever his opportunity cost is less than the CAB incentive because in that case his expected payoff π_i is always greater than or equal to zero:

(1) $E(\pi_i) = p * (S^{CAB} - OC_i) + (1 - p) * 0.$

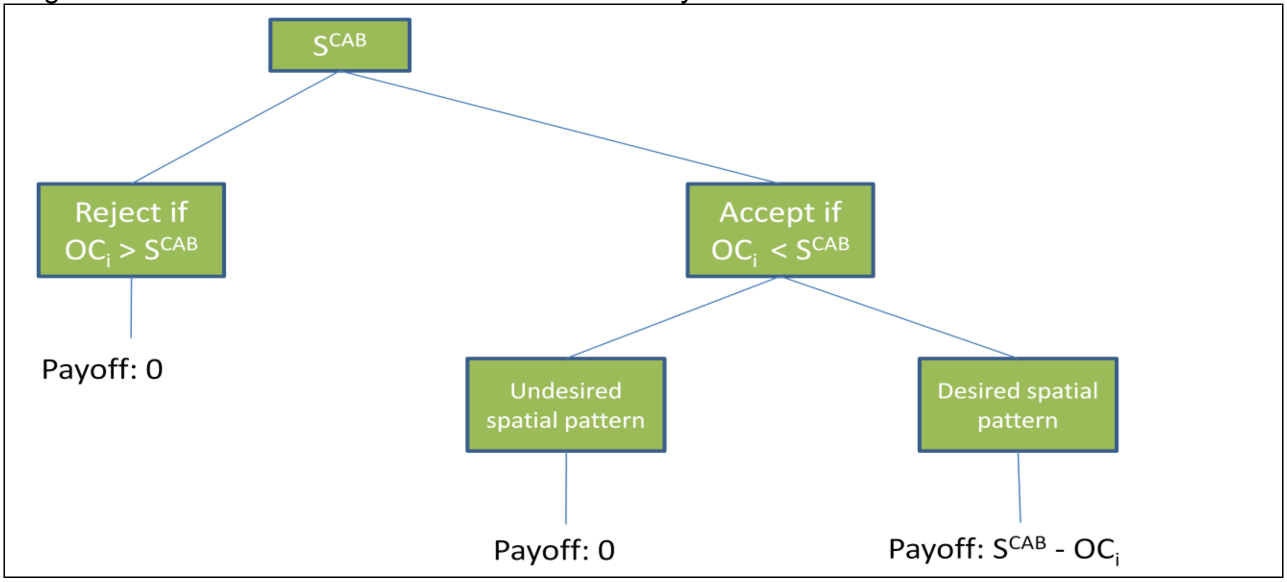
Where S^{CAB} denotes the CAB bonus payment, landowner i's opportunity cost of enrolling is OC_i, and p is the probability that his neighbors' enrollment will be sufficient to generate the regulator's desired pattern of conservation.

Under the CAB program a landowner's expected payoff remains a function of his neighbors' opportunity costs; they affect the probability that the agreement to enroll will become binding. However, information about neighbors' willingness to enroll (i.e. p) is no longer relevant to a landowner's enrollment decision. The probability p affects only the magnitude of the expected payoff. The sign of the expected payoff, which determines whether or not landowner i will conditionally enroll, is determined entirely by the landowner's opportunity cost and the size of S^{CAB}.[21]

Figure 2 below demonstrates the landowner's enrollment decision and payoff structure under a CAB program. Initially, the incentive S^{CAB} is offered. If S^{CAB} is less than landowner i's opportunity cost, then the offer is rejected and the payoff is zero. If landowner i's opportunity cost is less than S^{CAB}, then the offer is conditionally accepted. Finally, if an accepting landowner is part of the desired spatial pattern of conservation he is enrolled in the program obtaining a payoff of $S^{CAB} - OC_i > 0$.

[21] For the purposes of this paper, I assume that the CAB program is offered once and only once. If the CAB were offered periodically, a landowner may find it optimal to delay his enrollment decision, even where, if his option value is positive.

Figure 2. Landowner's Enrollment Decision and Payoff Structure



Figures 3a and 3b represent the operation of a CAB program on a hypothetical landscape. Figure 3a shows parcels of land conditionally accepting the CAB offer. That is, all parcels for which $S^{CAB} > OC_i$. Figure 3b shows the parcels of land ultimately enrolled in the CAB program when the desired pattern of conservation is three or more contiguous units of land. Any landowner not contiguous to at least two other parcels of land is released from his conditional enrollment.

What should be clear is that the CAB program functions *without* the coordination of landowners. Each landowner's optimal strategy (accept if $S^{CAB} > OC_i$ and reject otherwise) is informed only by his own costs and S^{CAB}. Information about neighbors' willingness to enroll, represented by p, is irrelevant.[22] Hence, the CAB can achieve desired patterns of spatially coordinated conservation *without* making any assumptions about the level of information available to landowners and their ability to cooperate.

From the landowner's standpoint, the conditional agglomeration bonus improves upon the agglomeration bonus as it has been represented in the literature in two important ways. First, the CAB simplifies the landowner's decision process by eliminating the need to coordinate one's decision with others. Second, the possibility of coordination failure caused by uncertainty of neighbors' willingness to enroll is eliminated. Wherever a group of landowners is each better off enrolling, that group is ultimately enrolled (see Figures 3a and 3b).[23]

[22] Under a standard agglomeration bonus the size of p is relevant to the enrollment decision, and the functionality of the agglomeration bonus will depend on each landowner accurately determining p. The information contained in p is complex: it is the joint probability of each landowner enrolling and it is endogenous.

[23] It is possible for some landowners to be thwarted by an irrational neighbor who does not enroll, but they will be no worse off than the status quo.

Figure 3a. Parcels Conditionally Accepting S^{CAB}

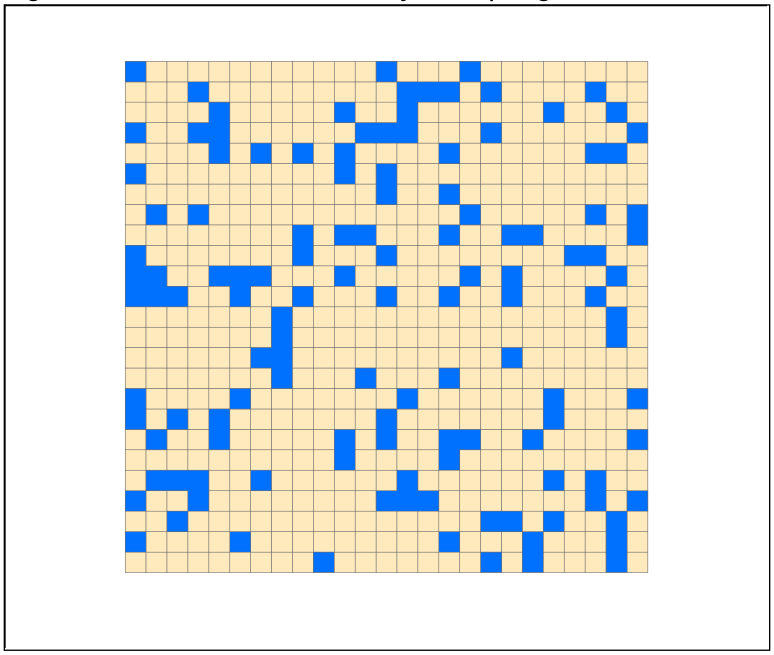
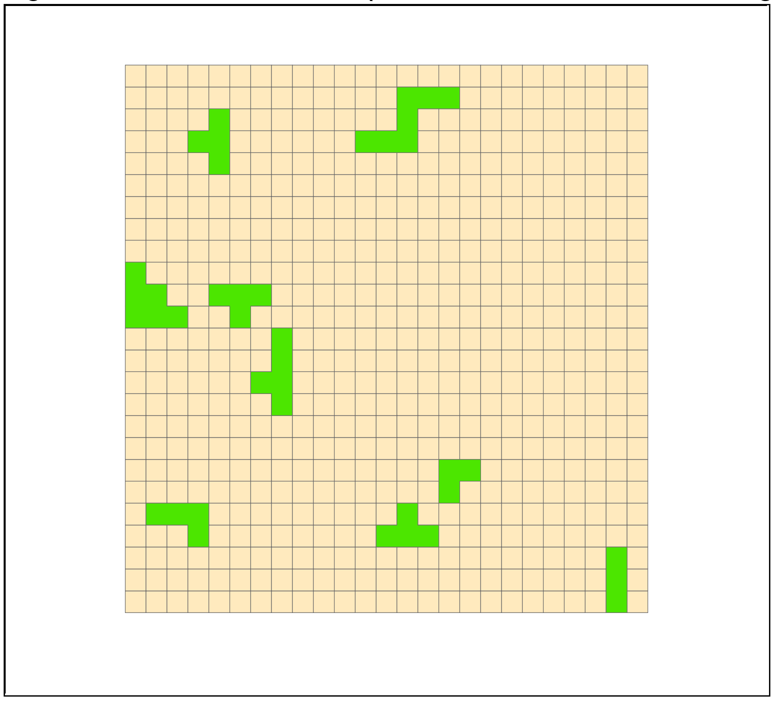


Figure 3b. Parcels Enrolled (criterion of at least three contiguous parcels)



Applications to Conservation

The ability of an incentive mechanism such as the agglomeration bonus to induce spatially coordinated land conservation does not alone recommend its application to conservation in the presence of threshold effects. The appeal of an agglomeration bonus incentive to a budget-constrained regulator will depend on how effectively it can be implemented. Factors affecting the efficiency of conservation incentive mechanisms that have been discussed in the literature include offsite environmental benefits, relationships between alternative environmental benefits, the correlation between land value and environmental benefits, threshold effects, and slippage caused by output price effects (Babcock, et al., 1997; Wu, 2000; Wu, et al., 2000).

Here the focus is on threshold effects and I assume that a single environmental benefit (e.g., habitat for a particular species) is being targeted. Suppose that the marginal benefit of conservation exhibits threshold effects such that the benefit per acre of conservation (BPA) is small until some threshold of contiguous acreage H_T has been conserved (see Figure 1). A cost effective allocation of conservation funds will target low opportunity cost parcels of land that form contiguous areas $H_j > H_T$.

In the context of the previous section, the CAB successfully targets high-benefit/low-cost parcels by identifying all parcels for which $OC_i < S^{CAB}$ (see Figure 3a), and enrolling only those parcels that contribute to the formation of contiguous areas for which $H_j > H_T$ (see Figure 3b). From the standpoint of a regulator, the CAB improves upon a standard agglomeration bonus by eliminating the possibility of coordination failure, which could result in the enrollment of fragmented parcels of land with small benefits. Allowing the final enrollment decision to be made after the spatial distribution of lower opportunity cost parcels is revealed enables the regulator to allocate funds exclusively to high-benefit contiguous parcels.

A difficulty faced by the regulator is how to choose the size of the incentive S^{CAB}. If the regulator knows the distribution of opportunity costs he may predict how many landowners will conditionally accept his offer of S^{CAB}. However, the number of parcels that satisfy the desired pattern of enrollment, and are ultimately enrolled and compensated, is unknown without knowledge of the spatial distribution of low opportunity cost parcels. For a given S^{CAB}, a landscape with spatially correlated opportunity costs will tend to enroll a large number of parcels compared to a landscape with spatially fragmented opportunity costs. Such uncertainty is likely to be problematic for a regulator facing a budget constraint.

The use of auctions in conservation contracting has been proposed in the literature as a way to overcome information asymmetry between landowners and regulators (Latacz and Hamsvoort, 1997; Romstad and Polasky, 2008). An *n*-price auction could solve the regulator's information problem by inducing landowners to reveal information about their true opportunity costs prior to choosing S^{CAB}. In an *n*-price auction, the level of compensation is set equal to the highest accepted bid. Each bidder has an incentive to bid his true reservation price because the level of compensation is independent of the size of the bid, except for the highest accepted bidder (Romstad and Polasky, 2008).

An *n*-price auction applied to this hypothetical conservation problem would produce the same outcome as a CAB program whenever the highest accepted bid is equal to S^{CAB}. The advantage of the auction is that it allows the regulator to set the level of compensation in accordance with his budget constraint. With information about the level and location of landowner opportunity costs revealed by the bidding process, the regulator would be able determine the levels of enrollment and total compensation resulting from accepting progressively higher bids. A level of compensation could then be selected that would satisfy the budget constraint.

Concluding Remarks

The importance of considering threshold effects in the geographic allocation of funds to land conservation has been well demonstrated in the literature. The agglomeration bonus is a targeting mechanism that attempts to spatially coordinate the allocation of conservation funds using a voluntary incentive mechanism. The primary weakness of the agglomeration bonus as it has been represented in the literature is that it requires landowners to do the coordinating amongst each other. Landowners may be able to coordinate enrollment decisions well, or poorly, depending on any number of conditions (e.g., the number of landowners involved). However, the possibility of coordination failure is always present and limits the mechanism's applicability to policy problems.

The primary contribution of this paper is to demonstrate that spatially coordinated land conservation can be achieved *without* landowners coordinating their enrollment decisions. Because a landowner's enrollment decision under a CAB program is determined entirely by his private costs and benefits, the possibility of coordination failure caused by uncertainty about others' willingness to enroll is eliminated. The elimination of coordination failure is attractive to both landowners and regulators. A group of landowners will want to participate in conservation whenever doing so results in each being better off. A regulator wants to enroll contiguous parcels of land while avoiding the enrollment of fragmented parcels.

In the limited context of targeting an environmental benefit exhibiting threshold effects, the cost-effectiveness of the CAB mechanism is attractive. A CAB identifies the spatial distribution of the parcels of land with lower opportunity cost and only enrolls those that satisfy the desired spatial pattern of conservation. That said, a host of other factors typically affect the cost-effectiveness of conservation strategies and a regulator must take those into account when considering a CAB. In some cases, it may be possible to incorporate a CAB into other incentive mechanisms such as competitive-bid auctions.

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Obesity Economics for the Western United States

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Introduction

The estimated obesity-related health care costs across the Western region in 2008 were $16.2 billion (this is an inflation-adjusted estimate based on the work of Finkelstein, Fiebelkorn, and Wang (2004)). [25] The Western populations, the percentage of obese adults in each state, and the estimated annual obesity-related expenditures by state are summarized in Table 1. The cost estimates include only direct health care expenditures related to obesity. The actual cost of obesity is much higher and includes not only obesity-related illness and disease, but also indirect costs resulting from missed work days and lower worker productivity as well as valued activities foregone as an opportunity cost (Trogdon et al., 2008).

One of the many challenges for nutrition and health policy in the Western United States is serving a diverse population. For example, 36.6% of California's population is of Hispanic or Latino origin, compared to the U.S. average of 15.4% (U.S. Census Bureau, 2009). Obesity rates differ across racial and ethnic groups. The adult obesity rates are higher among several groups, such as Blacks and Hispanics, when compared to the general population. Adjusting general state-level adult population obesity statistics for non-Hispanic white citizens, the percentage of obese adults in the population decreases to less than 20 percent in New Mexico and California. In Arizona, California, Colorado, Utah, and Wyoming, the prevalence of obesity among Hispanic adults is approximately five percentage points higher than the general population. The obesity gap increases for Blacks. The percentage of obese Blacks is five to 14 percent higher than the general adult population in Arizona, California, Colorado, New Mexico, Oregon, Utah, and Wyoming ((CDC/NCHS), 2009). [26] Challenges to effective obesity prevention in the West also include geographically isolated communities, diverse climates affecting the availability of fresh fruits and vegetables (FFVs), and substantial income disparities within communities.

The following review reports approximately ten years of work by economists, especially agricultural economists, studying obesity. We synthesize significant findings and identify potential areas of research need for the Western region. This review compliments work by Rosin (2008) surveying the economic causes of obesity and Philipson and Posner's (2008)

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[25] We define the Western United States as those 11 states in the Rocky Mountain Region and West, excluding Alaska and Hawaii

[26] Data is not available on the adult obesity rates for Blacks in Idaho and Montana ((CDC/NCHS), 2009).

review of economic explanations and interventions for the obesity epidemic. Our review builds upon these in consideration of the special needs and populations of the Western United States. We also include studies beyond those including theoretical models and general empirical studies. We incorporate health policy literature along with work by agricultural economists focusing on the possible role of agricultural policy in obesity.

Table 1. Overview Western United States Overweight and Obesity (2008)

State	Population	Percentage of Obese Adults in Total Population	Annual State Obesity-Related Health Expenditure
		(Percent)	(Millions)
Arizona	6,500,180	20-24	$937
California	36,756,666	20-24	$9,564
Colorado	4,939,456	15-19	$1,089
Idaho	1,523,816	20-24	283
Montana	967,440	20-24	$218
Nevada	2,600,167	25-29	$420
New Mexico	1,984,356	25-29	$404
Oregon	3,790,060	20-24	$973
Utah	2,736,424	20-24	$490
Washington	6,549,224	25-29	$1,657
Wyoming	532,668	20-24	$108

References: ((CDC/NCHS), 2009; E.A. Finkelstein, Fiebelkorn, & G.Wand, 2004; Eric A. Finkelstein et al., 2004; U.S. Census Bureau, 2009)

[a] The estimates are based on those of Finkelstein, Fiebelkorn, and Wang and inflated from 2003 estimates to 2009 dollars assuming a 4.5 percent inflation rate for medical expenses

Review of Literature

We divide the economics and health policy literature into five main categories. First, we consider economic research findings using structural and neoclassical productivity growth models. Then we review findings from studies focusing on labeling and consumer choice relationships to weight and health. The third category includes studies focusing on the effects of community and school environments on adult and child weight outcomes. Another area relates to intra-household economic processes and the weight outcomes for mothers and children. Finally, we review literature on issues at the intersection of food and fitness-based weight interventions and health care policy and procedures.

Productivity Growth Analysis

Advances in technology affect the affordability and availability of food as well as the degree of individual inactivity (Philipson & Posner, 2008). Over time, food has become cheaper while exercise time is more costly. According to Lakdawalla and Philipson (2002), much of the obesity epidemic may be caused by factors affecting consumer demand. They find approximately 60%

of the cause of obesity may be explained by demand-side factors while around 40% of obesity may be attributed to supply-side factors. They speculate decreased food prices, spurred by agricultural technology innovation, may increase the likelihood of obesity. This makes gaining weight less expensive. Individuals, especially underweight individuals, will gain weight until the marginal utility of weight begins to decline. The authors report a long-term decrease in physical inactivity caused by technological change, especially in the workplace technology, increases the probability an individual will become overweight. This robust result is from empirical analysis controlling for the effects of demographic factors such as income and education.

The technology and productivity growth approach was adopted by Alston, Sumner, and Vosti (2006) to measure the role of agricultural research and development expenditures on obesity. Some suggest obesity rates have risen because the prices of energy dense foods have fallen while healthier foods are more expensive (Drewnowski, 2003; Philipson & Posner, 2008). Alston, Sumner, and Vosti (2006) find this is not the case. From 1980 to 2005, the real prices of all foods generally fell, including many FFVs. They find the effect of agricultural policies is not clear. For example, the price of sugar, one of the most protected commodities, has generally fallen along with general prices of FFVs, meat, and fish. The increased year-round availability of certain FFVs, like strawberries, is an additional benefit of technological change in agriculture and transportation systems. In conclusion, economic analysis considering lower food prices as a function of technology growth refutes the notion low food prices lead to a more obese population.

Labeling, Taxation, and Consumer Choice

Economists have conducted informative research for possible food labeling, advertising, and taxation policy. Labeling investigations, grounded in asymmetric information theory, are motivated by the notion that people's health may improve if they are able to accurately judge the nutritional value of the food they are eating (see Akerlof, 1970). Frazao and Allshouse (2003) found consumers may have misconceptions or misinformation about the nutritional content and quality of the foods they consume. The implications of this misperception for health are ambiguous. For one, other food attributes, such as taste, convenience, and cost, may outweigh the benefits of healthy food intake. Simple health claims (e.g., oatmeal is "heart healthy") do not have a statistically significant influence on consumers' purchase of restaurant foods. However more complete nutrition label information (e.g., the grams of saturated fat in oatmeal) does influence purchase intent (Kozup, Creyer, & Burton, 2003). Few studies, however, have examined the impact of labeling on obesity. Variyam and Cawley (2006) looked at whether the move to a mandatory, standardized nutrition fact panel required under the Nutrition Labeling and Education Act (NLEA) had an impact on body weight. They found that the new labels led to significantly lower BMIs and probability of obesity, but only for non-Hispanic white females. Drichoutis, Nayga, and Lazaridis (2009) also conclude that the use of nutritional labels does not affect BMI.

Recent work on food advertising clearly supports policy to limit fast-food advertising to combat obesity. Richards and Padilla (2009) used Canadian data to show fast-food advertising increases overall demand for fast food in the general population. Chou, Rashad, and Grossman (2008), estimated the effects of a fast-food advertising ban on childhood overweight and obesity in the United States. They found such a ban would decrease the number of overweight 3-11 year-old children by 18 percent. The number of overweight adolescents would decrease by 14 percent. Research outside of the United States supports tighter food advertising regulations, especially for advertising to children (Chang & Nayga, 2009; Garde, 2008).

Food taxes are often proposed as a means to depress the intake of high fat and sugar-laden foods. Thus far, research on taxing less healthy foods does not support taxation, but rather subsidization of healthy foods, such as FFV, is recommended (Lochhead, 2009). Kuchler, Tegene, and Harris (2005) find that dietary changes resulting from a tax on salty snacks would be very small. Taxes are predicted to decrease the amount of sugar consumed, but not necessarily for all consumers and may have unintended consequence, such as increasing fat consumption (Nordstrom & Thunstrom, 2009; Smed, Jensen, & Denver, 2007). Several studies suggest that a FFV subsidy may be efficient, because it would reach several high-risk population groups, such as blacks, whites, unemployed consumers and consumers, who do not consume enough fruit and vegetables (e.g., Cash, Sunding, & Zilberman, 2004; Schroeter, Lusk, & Tyner, 2008; Sturm & Datar, 2005). A FFV subsidy could encourage consumption of these and decrease the intake of high-calorie fast foods. Overall, subsidies on low-calorie food are progressive and would provide health benefits to all consumer classes, independent of income. However, the greatest benefit would be experienced by low-income consumers (Cash et al., 2004).

Community, Education, and the Environment

Next, we examine what is known about school and community nutrition and physical activity environments and the impact of these environments on obesity. Researchers have focused considerable attention on the link between obesity and the built environment.[27] With regard to urban sprawl, researchers conclusively find residents of less sprawling, more walk-able neighborhoods report more minutes of physical activity and lower obesity prevalence than residents of more sprawling neighborhoods with lower walk-ability (Giles-Corti & Donovan, 2003; Saelens, Sallis, Black, & Chen, 2003). Furthermore, increases in car travel time are associated with increased probability of obesity (Amarasinghe, D'Souza, Brown, Oh, & Borisova, 2009; Frank, Andresen, & Schmid, 2004). However, Eid (2008) finds no evidence urban sprawl actually causes obesity, but rather people pre-disposed to obesity self-select into sprawling neighborhoods.

Neighborhood and socioeconomic characteristics also appear linked to obesity. Researchers consistently show that living in an area of poverty increases a person's odds of being obese (Black & Macinko, 2008; Booth, Pinkston, & Poston, 2005). Often, low-income people live in communities deficient of physical infrastructure needed to promote a healthy lifestyle. This trend is most severe in extremely urban and rural communities. The local food retail formats are not supermarkets with diverse food offerings, but smaller convenience-sized stores with a limited assortment of affordable FFVs (Baker et al., 2006; Block & Kouba, 2006; Horowitz, Colson, Hebert, & Lancaster, 2004; Moore & Diez Roux, 2006; Morland, Wing, Roux, & Poole, 2002; Powell, Slater, Mirtcheva, Bao, & Chaloupka, 2007). Poor neighborhoods also confront barriers to physical activity. These areas tend to provide fewer physical activity resources and often have unsafe conditions and dangerous neighborhood environments (Ross & Mirowsky, 2001; Wilson, Kirtland, Ainsworth, & Addy, 2004). Given this, it is not surprising that low-income neighborhood residents are less active (Yen & Kaplan, 1998).

Communities may rely on school-based policies to prevent childhood overweight and obesity. The two primary areas of intervention include the school food environment and physical

[27] Sallis and Glanz(2006, p. 90) define the built environment as "neighborhoods, roads, buildings, food sources, and recreational facilities in which people live, work, are educated, eat, and play."

education. While policies have focused on increasing the nutritional content of school nutrition programs, there is no definitive evidence on whether participation in programs such as the National School Lunch Program (NSLP) or School Breakfast Program (SBP) is linked to weight status. Early studies on this issue suffered from serious methodological problems including selection bias, incomplete participation data, and lack of measured height and weight data (Gleason, Briefel, Wilson, & Dodd, 2009). This led Fox et al. (2004) and Linz et al. (2005) to conclude that there is no definitive evidence linking participation in school nutrition assistance programs with children's weight status. More recent studies address the methodological issues, but offer no definitive conclusions. Schanzenbach (2009) finds that despite beginning kindergarten with similar BMIs and obesity rates, children who consume school lunches are 2 percentage points more likely to be obese by the end of first grade than those who bring their lunch from home. After accounting for selection, Millimet, Tchernis, and Husain (2008) conclude that participation in the SBP is not a contributing factor to childhood obesity, but participation in the NSLP is a contributing factor. Hofferth and Curtin (2005) find no evidence that participation in the SBP and NSLP is associated with increased likelihood of obesity among low-income children while Gleason et al. (2009) find no relationship between NSLP participation and obesity and that SBP participation is associated with a significantly lower BMI.

Others researchers have examined the availability of food and beverages in schools beyond school lunches. Anderson, Butcher and Levine (2003) address a variety of issues including increased access to vending machines in schools, brand name fast food in schools, "pouring rights" contracts, and beverage advertising in schools. While the percentage of elementary and middle schools with vending machines has increased since 2000, the percentage of high schools with vending machines has fallen and the number of states and school districts prohibiting access to junk food in school settings for at least part of the day has increased (P. M. Anderson et al., 2003; O'Toole, Anderson, Miller, & Guthrie, 2007). Anderson and Butcher (2006) examine the effect of increased access to junk food in schools on students' BMIs and find that for students with normal weight parents there is no effect, but for students with an overweight parent, a ten percentage point increase in access to junk food in schools leads to a greater than 2 percent increase in students' BMIs.

School physical education (PE) programs have also been at the forefront of policies to reduce childhood obesity. Reduced PE in schools has been hypothesized as a contributing factor to overweight and obesity among children leading to increased or reformed PE in many states (Cawley, Meyerhoefer, & Newhouse, 2007). However, when Cawley, Meyerhoefer, and Newhouse (2007) examine the impact of state laws on time active in PE and the effect of PE on overall physical activity and weight in high school students, they find little evidence that PE impacts weight. They conclude that while state PE credit requirements are effective in increasing the active time spent in PE, there is no evidence that such time affects BMI or the probability of being overweight or obese.

Family and Household

Analysis of household decision processes and obesity is evolving. For some time, economists have noted family membership influences individual health status and an important function of families is the production of nutrition, rest, and leisure time—all of which are pertinent to the obesity discussion (Becker, 1991). Data limitations, however, tend to prevent empirical analysis of intra-household allocation processes and their effects on obesity. Ehmke et al. (2008) propose the use of economic experiments to analyze family decision processes and dynamics related to food and fitness. Such work reveals there are connections between mother-child bargaining behavior around food and their weight outcomes. Households with incompatible, conflict-prone mother-child bargaining behavior tend to have poorer health outcomes (M. Ehmke, Schroeter, Morgan, Larson-Meyer, & Ballenger, 2010; M. D. Ehmke, Morgan, Schroeter, Larson-Meyer, & Ballenger, Forthcoming). These findings are consistent with findings from the literature on child food and feeding (Birch & Fisher, 1998; Davison & Birch, 2002; Faith, Scanlon, Birch, Francis, & Sherry, 2004).

A noticeable structural change over the last thirty years is the increased numbers of working mothers. Researchers do find a link between maternal employment and childhood overweight and obesity. Children of mothers who work do suffer a slightly higher probability of becoming obese. Curiously, the child weight effects of a working mother are most pronounced in affluent households. Children in higher-income households see a 3.5 percent increase in the likelihood they will be obese for every 10 additional hours their mother works per week (P. Anderson, K. Butcher, & P. Levine, 2003; P. M. Anderson et al., 2003; Fertig, Glomm, & Tchernis, 2009).

Health Care

The obesity epidemic brings food and agricultural policy into the health policy sphere. Currently, the medical community faces many challenges as it tries to halt obesity’s momentum. Primary health care providers’ role in obesity management remains unclear and warrants serious consideration by health experts and economists. Adult and pediatric clinical practice guidelines recommend that providers screen and counsel patients regarding overweight and obesity (Barlow & Committee, 2007; U.S. Preventive Services Task Force, 2003). Yet, there is growing skepticism over the utility of these recommendations.

Health providers are not consistently documenting or counseling their overweight and obese patients, especially such pediatric patients (O’Brien, Holubkov, & Reis, 2004). Providers often fail to screen for and/or diagnose their adult and pediatric patients with overweight and obesity. In addition, providers often neglect to counsel patients who are overweight or obese (Jackson, Doescher, Saver, & Hart, 2005; O’Brien et al., 2004; Waring, Roberts, Parker, & Eaton, 2009). This omission likely stems from a variety of reasons including but not limited to short patient visit times (Tsui, Dodson, & Jacobson, 2004), lack of knowledge regarding effective weight loss strategies (van Gerwen, Franc, Rosman, Le Vaillant, & Pelletier-Fleury, 2009; Vetter, Herring, Sood, Shah, & Kalet, 2008), and negative stereotypes regarding overweight and obese individuals (Ferrante, Piasecki, & Ohman-Strickland, 2009). When they do offer counsel, the patients may lack the motivation or incentives needed to carry out lifestyle changes.

Right now, it does not appear primary health care providers have the training necessary to support provider-based health intervention. A recent systematic review found that current individual physician-based weight loss counseling with obese adults was largely ineffective (Tsai & Wadden, 2009). Similarly, a review of interventions for overweight and obese children and adolescents found that the most effective interventions occurred in schools and specialty settings (e.g., programs and locations designed around healthy lifestyle enhancement), not in the offices of primary care providers (Whitlock, O’Connor, Williams, Beil, & Lutz, 2008).

It is critical that we ascertain how best to prevent, diagnose, and effectively manage overweight and obese individuals. Society and the media encourage people to “talk to their doctors” regarding weight management issues. However, providers often fail to screen or diagnose patients with overweight or obesity, and when they do; they may not be using the best methods for determining true adiposity. In addition, current evidence does not support the efficacy of a provider-based counseling for the management of overweight and obesity. Rather, the most compelling evidence supports programs that are focused on changing the behavior, which are often led by experts in exercise, nutrition, and psychology (Galani & Schneider, 2007; Wilfey et al., 2007).

Conclusions

The obesity epidemic has pervaded society at a fast rate and researchers have struggled to determine the possible causes of its momentum. Our review of the current literature reveals a few, known links between obesity and food and agriculture policy. First, fast food advertising has been shown to increase consumer demand for fast food products. Second, obesity is not simply a function of cheaper calories. Policies have caused “healthy” as well as “unhealthy” food prices to fall. All food, in general (but not across the board) is less expensive (Alston et al., 2006). It seems food advertising may route consumers more toward high-fat and calorie laden foods. Third, taxing fat, salty, and sugary foods does not appear to be a powerful means to curb consumer demand for such foods although the revenues generated from taxes on such foods could be used to fund health promotion programs (Jacobson & Brownell, 2000; Kuchler et al., 2005). Rather, subsidizing fresh fruits and vegetables and other healthy foods appears to be a more viable retail-level solution. Finally, there is a relationship between neighborhood safety and availability of fresh produce and obesity in extremely rural and urban areas.

Findings from our literature review suggest obesity-prevention policy in the West should consider the societal costs of food advertising, especially to high-risk populations. At a state and community level, resources need to be aligned to help geographically based high-risk populations, especially those in extremely rural or urban areas. Although states (e.g., California) are considering taxes on sugary or less healthy foods to finance obesity prevention, food subsidies may be the most effect first line of defense again obesity at the food-retail level. Finally, health care providers in the West need additional resources and perhaps training for patient counseling regarding healthy weight loss and healthy lifestyle improvements. This may be especially true for providers working with obesity-prone populations.

Other areas of study reveal more ambiguous findings. For example, there is a slight relationship between working mother status and child weight status, but it does not explain a majority of the rise in childhood overweight and obesity. Regarding childhood overweight and obesity, school lunch and physical exercise policies appear effective only to a point. Children do consume a majority of their calories at home (Story, 2009). There is a dearth of data on intra-household allocation processes and their effects on obesity, especially childhood obesity. What is available, shows parent and child economic behavior play a role in the health outcomes of families’ decisions.

More research is needed from agricultural economists, in particular, on the effects of food labeling on obesity. In particular, why do the benefits of the NLEA regulations appear to accrue to only one demographic group (Variyam & Cawley, 2006), and what types of information will really change behavior and produce measurable health outcomes, especially for susceptible groups in the Western United States? Furthermore, Drichoutis, Nayga, and Lazaridis (2009) note the need to examine the effects of nutritional information in restaurant and fast food settings on weight outcomes, although currently no dataset exists that would enable this analysis. Additional investigation is needed to link clinical dietary recommendations and weight control practices to patient lifestyle change. Although primary care providers receive directives to be aware of obesity in their patient population and encourage healthy lifestyles, they experience many obstacles in their ability to change patient lifestyles.

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