Case study:

The prospects for management of a fragmented aquifer by a divided farm community

Anne MacKinnon. Adjunct professor, University of Wyoming School of Environment and Natural Resources. *
amack@vcn.com

1. Introduction

The extreme south-eastern corner of Wyoming, an area of high flat prairie, bluffs, and streams that disappear into sand on occasion, has become farmland through exhaustive pumping of underground water resources. The groundwater aquifer, ever unpredictable and only erratically productive, now appears to be seriously depleted.

Whether the farmers in the area can find a way to work together to manage what remains of their water resources and keep farming the major question facing the area. With business, services and young people increasingly focused on nearby metropolitan areas, and local farm products limited to low-value crops, residents have for some time been haunted by the prospect of their community withering away economically and socially. (Wyoming Rural Development Council, 2003, p. 40) As water supplies drop, that question becomes literal - and vivid.

The aquifer that all farmers use has a peculiar structure that makes it difficult to predict whether usage cutbacks or recharge efforts could stabilize the water supply. The community also has its own internal differences, which may make it impossible to pull together to avoid dissolution. Composed of disparate family groups scattered over the landscape, the community appears to have been atomized as each farmer experiences a different degree of dwindling water supply. Broadly, however, the farmers seem to fall on either side of a socio-economic boundary line,

Larger, more prosperous farmers embrace out loud the prospect that each family, and each farm, must stand or fall on its own. Clearly they mean that they themselves expect to remain standing whatever comes next. Smaller farmers with fewer resources see the most value in a community-wide solution. They won't, however, commit what time or money they have to such an effort unless they see the larger farmers willing to sacrifice in an attempt to make agriculture in the community sustainable for all.

* The author is member and past chair of the Wyoming Water Development Commission, which plays a role in the events described in this paper.

The key institution now in place for managing water in the aquifer was created over 30 years ago to prevent depletion but has failed to do so. That appears to be in part because it was a top-down and centralized solution that does not truly give the water users scope for collective decision-making and action. Its structure, dictated from above, also reinforced the local divide between larger and smaller farmers. Yet a further problem has been that this existing institution has not provided the water users with continuing monitoring data to demonstrate depletion rates and the impact the farmers' water use has on the aquifer.

Jointly, the farmers could possibly create for themselves a new institution that could both encourage less water-intensive farming techniques and manage the aquifer. Such an institution might prevent further dwindling of the underground water supply and perhaps even restore some of what has been lost. The existing legal framework in which the farmers operate would allow local creation of such an institution.

Will the farmers act collectively to create an effective new governance system? A look at the overall setting in which these farmers work - examining the whole "social-ecological system" (SES) surrounding this place and its problems – suggests what is needed for collective action to take place. (The term SES, of course, is Elinor Ostrom's, from her 2007 paper outlining a framework for analyzing complex social-ecological systems. (Ostrom 2007) Her proposed framework has proved very useful in understanding this situation, transforming it from a local story to a description of a system with gaps and strengths that can be highlighted and compared to those of other systems.

Looking at this problem with the aid of Ostrom's framework, one key factor emerges as a crucial precondition for these water users to undertake collective action.

The farmers need information on the local aquifer specific to the locations of the larger farmers. If that information is developed and forecasts water supply declines that those farmers would consider drastic – declines they can't make up for with deeper wells or better pumps – it could spur the larger farmers to make a genuine commitment to a community effort to manage the aquifer for the benefit of the entire community. With such an effort underway, what's needed next is to create among all farmers an increased and shared understanding of their overall groundwater situation.

The community thus far has taken one hesitant step to develop a collective action solution, with a few volunteers at a public meeting in early 2009 agreeing to meet again as a core group to draft a plan. The outcome of that effort will be determined well after the date of delivery of this paper.

This paper analyzes the factors at play to identify what appears necessary for this community to take collective action to manage its water resource.

2. The setting
   2.1 The water resource – system and supply

Small streams fed by snow in mountains some 70 miles west bring some water to the high-altitude plains of far south-eastern Wyoming. The early beginnings of the town of Pine Bluffs, the social center of the area, are traced to thirsty Texas longhorn cattle who passed through the area on their way north from the early 1860s until the 1890s. After long, dusty, dry days on the trail, the big herds stampeded to drink from Lodgepole Creek near the town's namesake bluffs covered with pine trees.(Thompson 1967) p. 25 But the streams are small, and precipitation is sparse – an average of about 15 inches per year, defining this as a semi-arid zone. (Dahlgren 2001, II/11) (Curtis and Grimes 2004) (pp. 3, 252) Early farm settlers found they needed to dig wells and build small windmills to get drinking water; most grew crops like winter wheat that could survive on the slight local rainfall.(Thompson 1967)(pp. 6-7).

Groundwater is the prime water source in the Pine Bluffs area. The early farm drinking-water wells tapped an aquifer known locally as the "White River" or "Brule" formation. Nearby – but not close enough - it is possible to drill into an aquifer famous for its reliable production, the Ogallala, the largest groundwater aquifer in North America, that can reach nearly 400 meters (over 1300 feet) thick, and covers 453, 250 square km (175,000 square miles)(Cech 2003) (97). That aquifer largely eroded out eons ago around the Pine Bluffs area, however, and all that remains for local farmers to tap is the White River, a formation that elsewhere is covered by the Ogallala.

The White River formation is notorious for its spotty production record.(Dahlgren Consulting, Engineers et al. 2001) (p. II/16-17) Geologists explain that the White River formation provides substantial water supply only in "fracture" and hollow "pipe" zones found in the siltstone formation, which is composed of tiny "fines" of volcanic ash and other materials. The fractures and pipes don't necessarily communicate with each other. Whether a White River formation well will have high water capacity depends on whether the well happens to hit a pipe or fracture. (Dahlgren Consulting, Engineers et al. 2001). (p. VI/1) Lidstone 1995. 1-3 (Associates 1995; Lidstone 2009)

Over time, people trying to farm the area have built increasingly advanced facilities to take advantage of what water they could find in this formation. Early in the 20th century the hand-dug wells and windmills for drinking-water and home gardens were increasingly replaced by mechanically-drilled wells and electric pumps to bring up water to irrigate crops. "Dry-land farm" fields like winter wheat (depending upon rainfall alone) were replaced by fields of irrigated crops producing alfalfa hay, small grains or beans. In their turn, those fields produced

more crops via electric-powered irrigation sprinkler systems, fostered by government subsidy programs in the 1960s and 1970s.(Thompson, 27-31; Aiken, 980, ftnt 87).

With considerable farming underway, even by 1917 Lodgepole Creek was known to disappear, surface, and disappear again.(Dahlgren Consulting, Engineers et al. 2001) (II/1, citing 1917 observer). Such impact on a stream is typically an early sign that groundwater pumping is extracting water that previously would have recharged the aquifer. (Aiken, 969, 972-3)The area around Pine Bluffs has since become one of the most intensively farmed areas in the state. Ranches for livestock grazing predominate statewide in Wyoming's high, cold climate, except for a few irrigated oases. Most of those irrigated lands in Wyoming tap surface streams, from snow melting in the mountains. The Pine Bluffs irrigated fields are unique in Wyoming for their near-complete reliance on groundwater for irrigation. Lodgepole Creek, as it emerges from low mountains to the west, typically carries an estimated 5,000 acre-feet of water each year of snowmelt (6.175 mcm) (Dahlgren,2001, II/3-4). But by the 1970s, use of groundwater in the Pine Bluffs area amounted to nearly 22,000 acre-feet (about 27 mcm) each year – more than four times the amount of water that the creek could have carried. (Dahlgren 2001, II/3, citing 1972 study).

The heavy water use has taken a toll on the water available in the White River formation. From 1979 to 1995, overall water levels in area wells were estimated to have dropped about four feet. (Lidstone 1995, 3). By 2001, in a study of the potential for a project to import water to recharge the aquifer and perhaps halt its decline, engineers estimated that up to about 5,000 acre-feet (about 6.175 mcm) per year (the whole annual snowmelt flow into Lodgepole Creek) would have to be delivered back into the aquifer to achieve that goal. (Dahlgren, V/1) Under current practices, it is clear that supplies are declining rather than growing. Rather than water extracted from the aquifer being replaced, and the system kept close to equilibrium, water is being "mined" – or extracted beyond the aquifer's capacity for recharge.

The groundwater around Pine Bluffs is heavily used, but it is not of great economic value under current uses in this location. Sales of the water alone, if any, are not traceable – and practical obstacles to such sales abound. Analysis of sales of land with and without water rights would have to be compared to arrive at an estimate of the market value of the water. However, an estimate of the water's economic value for the purposes of this paper can be derived in other ways. The crops the water produces are of relatively low value: primarily hay, corn, winter wheat, dry beans and sugar beets (in that order of magnitude). (Dahlgren, III-3) As a producer of those crops, the groundwater has an estimated value of about $48/acre-foot (under 37 Euros per thousand cubic meters), based on recent figures on area use of irrigation water and local crop values.[†] Further,

[†] The 2001 study of the potential for aquifer recharge (Dahlgren 2001) estimates area water use at about 1.3 feet of water per acre per year. The study notes that with this amount of water use, the crops produced are

local farmers in 2001 indicated to researchers that $162/per acre foot/year (nearly 125 Euros per thousand cubic meters/year) would be more than they would be willing to pay to import water in order to undertake the proposed recharge project and attempt to prevent further decline in their water supplies. (Dahlgren, VII/3-5) For comparison, the price per-acre foot per year that farmers in California's San Joaquin valley (with much higher value crops) have paid for water ranges upwards from $280 per acre-foot. (Womack 2009)

2.2 The water governance system

A water governance system specifically aimed at preventing decline in groundwater supplies has been in place in the Pine Bluffs area for nearly 40 years. It has failed.

The governance system in place for groundwater in this area is extraordinarily simple, flat and centralized. It contrasts with the more complex, nested system long in place in Wyoming for governance of surface water.

For surface water, Wyoming has a nearly 120-year-old system which allocates key property rights to water resources between a governance agency and the water users. (MacKinnon 2006) pp299-301, 318-319 The governance agency holds, among other powers, the important right of exclusion: it is the sole authority that determines who can and cannot have a water right, and how much water a user can take. The system includes a monitoring and sanctioning process, but that process is ordinarily set in action only if invoked by the users. The governance agency operates through a set of local networks, through locally-based superintendents and their staff who know most users personally. (MacKinnon 2006) 318-321 Early attempts at creating a centralized governance system fizzled due to the superintendent-staff involvement in local affairs, lack of funding, and in-practice reluctance to pursue sanctions absent local user demand. (MacKinnon 2006 op cit) As a result, both collective-choice and constitutional rules that evolved in early years of system implementation give water users considerable influence over how water is used and what standards will govern its use.(MacKinnon 2008) pp 12-13 The system has some of the features of the nested systems scholars have found to have value in governing natural resource use. (Ostrom 2005, p.258)

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probably somewhat water-stressed and of less value than they would be if they received all the water they could consume. (Dahlgren, III/8-9) The 2007 U.S. Census of Agriculture presents figures on the value of crops produced in the county and the total acreage used for those crops (Agriculture, U. S. D. o. (2007). "Census of Agriculture: County Profile: Laramie County, Wyoming." from www.agcensus.usda.gov/Publications/2007., accessed 3-13-08: County Profile, Laramie County, Wyoming) From the census figures, the value of crop sales in the county per acre used for crops comes to about $63 per acre. The 2001 aquifer recharge study asserts (in the course of estimating water demand) that the types and proportions of crops produced is approximately the same in the Pine Bluffs area as in the county as a whole, though the total acreage put into such crops may be higher in the more "intensively farmed" area around Pine Bluffs. (Dahlgren, III-3). Accordingly, the $48/acre-foot value for water appears a reasonable estimate for the value of groundwater as currently used in the Pine Bluffs area.

That description, however, applies only to the Wyoming system for governing surface water, the most heavily-used water resource in the state. Groundwater, the resource upon which Pine Bluffs irrigators uniquely rely, is subject to a system similar on paper, but not in practice.

Groundwater was not recognized as subject to the overall water governance system in Wyoming, in law or in practice, until 1945. By that time the governance system for surface water had already been operating for over 50 years. In 1945 the Wyoming Legislature began to take note of groundwater; in 1947 it enacted the first statute regarded as taking groundwater into the state water governance system; a more complete code followed in 1957.(Chaffin 1947)(111) Before 1947, Wyoming landowners were generally regarded as having a right to use groundwater beneath the surface of their land as an attribute of land ownership.(Chaffin 1947, 113-116; Hutchins, p. 156) Meanwhile state and federal investment in geologic studies showing the availability of groundwater encouraged more well development, particularly in eastern Wyoming. (Donahue, 1985, p. 278-80)

By the 1940s, increasing Western U.S. focus on the need to prevent waste of groundwater (dramatized by decades of waste and conflict in important farming areas in the southwestern U.S.) had led the head of Wyoming water governance agency to recommend that groundwater be taken into the governance system..(Renshaw 1963; Donahue 1985) (pp. 281-89). (Chaffin, p. 116; Hutchins, p. iii)

In 1945, the Wyoming Legislature responded by asking for hearings among groundwater users to determine their views on creating a groundwater governance system. Groundwater users were *not* very interested: in Pine Bluffs, where there was a major user turnout for the hearing, well-known farmers with large holdings were firmly opposed to any move to govern groundwater use. One large farmer said the water underground belonged to the person who owned the land. He suggested a local association of farmers might form to “handle any overdevelopment,” and he suggested drilling of a monitoring well, but he also noted he did not expect much more groundwater development in the area. In another major groundwater use area further north, one local legislator said governance of groundwater use was necessary to protect early users from over-development by later ones. Another local legislator, however, flatly opposed any governance. (Lloyd 1946) (pp 1-3) (Chaffin 1947, 116, espec note 35.)

Accordingly, in 1947 the step taken by the Wyoming Legislature toward groundwater governance did little but provide for recording of existing and new wells. Wyoming Session Laws (1947), ch. 107. The key power of excluding people from using water - a power held by the governance agency since1890, regarding surface water – was not allocated to the governance agency regarding groundwater until 1957. (WSA 41-3-905) Up to 1957, a farmer could still simply

decide to become a user, by drilling a well. In the 1950s, however, groundwater use increased with advancing technology in both well-drilling and mechanized irrigation and the experience of severe drought – while national policy pressure for groundwater management continued to mount. (Thomas, pp. 36-77) In 1957 the Wyoming Legislature enacted a detailed groundwater code which required a farmer to get a permit from the water governance agency in order to use groundwater. (Hinckley, Ch. 9, p. 1; WSA 41-3-905)

The 1957 statutes, still largely in place, also included provisions for creation of areas for special treatment of groundwater use ("control areas") where groundwater levels are declining or where use might soon exceed recharge. Local users concerned over potentially declining supplies can and typically have put together petitions to propose creation of such areas. Only the central governance agency itself can, however, actually declare a location to be a "control area." Three such areas have been created in the state. (WSA 41-3-912, 918; Hinckley 2009, ch 8 p. 10)

Once a control area is declared, the governance agency must determine the usage and date of first use of every existing well in a control area, and has authority to close the area to new wells. No one can seek permission to drill a well in a control area without the proposal being publicized and public comment sought before approval. (WSA 41-3-912)

The governance agency can hold hearings – and has to do so, if a group of users requests it - to determine if the groundwater supply in the area is sufficient to meet user needs. If – but only if - the governance agency finds that water supply in the area was insufficient to meet the needs of the users, it can impose restrictions on existing use, including shutting down a recently-drilled well that adversely impacts an adequate older one. (WSA 41-3-915a)

Regardless of whether there is evidence of insufficient supply, however, the Legislature also directed the agency to encourage users in a control area to come up with a groundwater management plan. The agency is directed to encourage user agreements for apportionment, rotation, or pro-ration of their water supply. Such agreements, once endorsed by the agency, would be enforced by the agency. (WSA 41-3-915c)

Each control area is to have an advisory board elected by landowners in the control area. (WSA 41-3-913) That board would make recommendations to the governing agency about whether to approve any proposal for a new well, and could propose use restrictions for the agency to consider. (WSA 41-3-915c; 41-3-932c)

Despite this detailed legislation, no control area was created in Wyoming for 15 years after its passage. Then, the first control area created was in Pine Bluffs -

due to evidence of declining water levels in irrigation wells in the area.(Hinckley 2009) (Ch 8, p 8)

It is significant, however, that both the written law and the records of local advisory boards make it clear that users can be consulted but are not directly involved in decision-making on groundwater in Wyoming. And indeed, in practice the involvement of water users has been strictly limited. Users can propose but not create a control area imposing stricter limitations on groundwater use. The boards elected by landowners have kept to their "advisory" role, and have had no authority to take collective action on behalf of the water users. Minutes of the initial years of the advisory board established in the Pine Bluffs area in 1971 (now absorbed into a larger control area and advisory board) - show staff members of the governing agency from the state capitol reminding board members that their function was only to make recommendations to the agency, on such issues as approval or denial of applications for new wells. Those were recommendations which the agency might or might not follow.(Board 1971-1981)

Records from the three control areas established thus far in Wyoming suggest that the advisory boards create a forum for public discussion, debate and education regarding groundwater, but not much more. Advisory board recommendations certainly do not bind the governing agency. In a number of cases where an advisory board has recommended denial of a new well, the agency has nonetheless permitted the new well – apparently in the belief that water supply was adequate and other users needed merely to deepen their wells in order to remain unaffected by new wells.(Hinckley 2009) ch 8 p. 14; Ch 9, pp. 8-9 On the other hand, in at least one area an advisory board recommended a set of limitations to be incorporated in permits for new wells which the governing agency did decide to adopt. (Hinckley 2009 ch 8 p. 16)

Wyoming groundwater management is also marked by the absence of the networking through locally-based officials who are close to users which is so noticeable in management of surface water in Wyoming. In surface water those relationships allow water users to be players in collective action decisions and even in the making of constitutional rules. (MacKinnon 2006 pp 306-309; MacKinnon 2008, pp 12-13)

In groundwater, however, those relationships are few, and it is the governance agency in the state capitol that takes action and is a key player in making constitutional rules. Groundwater management does not occur primarily through river basin superintendents and their employees. Rather, staff of the "Groundwater Division" from the state capitol come to meetings of the control area advisory board, make their own determinations and recordings of the extent of use by each user, and independently confer with users to answer questions about use and any conflict with other users. This may be in part due to the accidents of geography: heavy use of groundwater for irrigation in Wyoming is largely in locations without much surface water that near the capitol city in the far

southeast corner of the state. (That city, in turn, was located with little heed to water availability as an originally temporary service town for the railroad built to connect the eastern U.S. with California in the 1860s.) In the case of Pine Bluffs, water governance agency staff from the capitol are physically closer to the users than is the river basin superintendent, headquartered further north along a major river. The other two groundwater control areas in the state are also within relatively easy reach of the state capitol. Statewide, independent of geography, the pattern remains the same: it is primarily central agency staff that deal directly with groundwater issues. (The agendas for the quarterly meetings of the board that establishes, changes and eliminates water rights for the state make this clear: all ground water matters are presented as a group, separate from surface water matters, and they are presented by central agency staff rather than by the river basin superintendents who personally present surface water matters.(Control 2009) pp 4-5, 43-49 Such a pattern has not created the conditions for groundwater users to take an active role in collective action decisions and constitutional rule-making, as enjoyed by Wyoming surface water users.

The central water governance agency in the capitol typically monitors groundwater use in three situations: 1) where conflict with another state (as, Nebraska, to the east of Wyoming) has led to agreements to limit and report groundwater usage (States 2001) Sections IVA, VIIIA ; 2) with general monitoring wells aimed at observing changes in overall groundwater levels, often in a control area; 3) in response to user claims of conflict with another user. Groundwater users are typically not required to file reports of how much water they extract with their wells. Accordingly, even in a control area like Pine Bluffs, the governance agency has estimates but not actual data on total groundwater usage.(Discussion 2009) (Dahlgren 2001, II/3)

The same pattern is true of surface water governance – general monitoring becomes more specific only on the emergence of conflict, often on complaint of a water user. In surface water, however, years of experience with conflict and water shortages in a number of watersheds have resulted in large numbers of measuring devices installed on surface streams.(Tyrrell 2009) Reports from those measuring devices allow relatively accurate estimates of surface water usage by location, statewide.

In groundwater, meanwhile, partly due to the difficulty and expense of determining the scope of underground supplies and the potential interaction between wells, considerably less monitoring and enforcement has occurred. Indeed, establishment of a control area for groundwater can contribute to lack of enforcement, and leave water users powerless to prompt enforcement. In non-control-areas, one groundwater user can complain of another's interference with his water use. If the agency finds the other well has caused depletion that can't be remedied by simply drilling a deeper well, production from the "interfering" well can be cut back or shut down. (W.S.A. 41-3-91) In a control area, the statutes

authorize the central agency to shut down a well that depletes another, senior well *only* if the agency has already done a full study of the adequacy of groundwater supplies in the entire control area. (WSA 41-3-915a) No doubt the writers of the statute in 1957 believed that such studies would quickly follow creation of control areas. In fact, however – whether due to lack of funds or lack of local interest - the central governance agency has not done studies of the adequacy of groundwater supplies for any of the three control areas. Accordingly, in those areas the prerequisite is absent for enforcement that would shut down a well that affects another, more senior well. In fact, in a case a few years ago southwest of Pine Bluffs, a senior well owner's complaint of adverse impact was therefore not followed with an enforcement action, for lack of the prerequisite study (Engineer 2004) p. 45

It becomes clear that from its beginnings in the 1940s, governance of groundwater in Wyoming has been highly centralized, with little development of collective action by actual users who have continued to operate within a flat, top-down governance structure.

2.3 The groundwater users

About 50 farmers use groundwater in the Pine Bluffs area. Some are families that first came to the area in the 1880s and 1890s, creating small ranches. Some are descendants of those who came around 1906-07, as part of a "dry farming" boom when farmers took up tracts sold by the transcontinental railroad that runs through the town, or lands offered by the federal government in return for establishing homes and farms. Some have come later. Many of those who came in the dry farming boom were disappointed and left; others stayed and bought up the abandoned farms. More farms changed hands in the depression of the 1930s – sometimes going to the farm families who also had the bank or a store in town. As technology and financing for well-drilling and irrigation advanced from the 1910s and '20s through the 50s, 70s, and 90s, the farmers who stayed on or moved in became irrigation farmers, heavily dependent on the latest pumping and sprinkler technology. (Aiken, p. 980) In recent years, since about 2000, a few new families have appeared – immigrants from nearby northeast Colorado farmlands, escaping growing urban development and irrigation water use restrictions there. There has been some consolidation of farms, among fewer owners. Long term residents sometimes complains that "new kinds of people" have moved in. (Wyoming Rural Development Council, 2003) (Thompson, pp. 4-16, 25-31) (Sundin 2009) (Lidstone 2009)(Lidstone March 2009) Census figures confirm these local reports: Over half the population in the town and the farming area surrounding it were born in another state, typically of Northern European ancestry. In 2000, 10 percent of the population in and around Pine Bluffs had arrived since 1995. (Census 2000)

The population of the town of Pine Bluffs is about 1,200 people. (Lidstone, 1995, p.1) The entire rural area surrounding and including the town numbers about 1,600 people. Census data indicate that average farm net income in the Pine Bluffs area is probably in the range of $35,000 – $40,000 per year, with average operator age of about 56 years (not unusual nationwide in the U.S.), most with about a high school education but no higher. (Agriculture 2007) (Census 2000)

Typical crop rotation patterns from the Pine Bluffs area – relying heavily on hay, rather than higher-value crops - seem to support the income figures. The typical rotation is roughly 3 out of 6 years in alfalfa hay, and 1 out of 6 years for each of wheat, dry beans, and corn used for grain. (Cochran 2009) p. 4.

In January, 2009, a meeting of irrigators called together by a state agency to discuss water shortage problems revealed a rift between larger and more-prosperous farmers and smaller farmers in the area.

The meeting was called not by the water governance agency but by a separate agency charged with funding water supply facilities (from large new dams to municipal well-fields to rehabilitation of irrigation diversion structures). The funding agency (the Wyoming Water Development Commission) called the meeting in response to request from the town of Pine Bluffs for a plan to ensure more reliable water supplies for the town. Reports indicated that town wells were declining like the irrigation wells, that the town had already undertaken conservation measures, and that, due to the nature of the aquifer, simply drilling more wells would not solve the town's problem. (Lidstone 2009) Irrigation wells in the area use the vast majority of the groundwater in use. The town has the legal right to force sale of agricultural water rights to keep up the town's supply, but townspeople did not wish to take that step. Accordingly, the funding agency agreed to help the town come up with a water supply plan but also called a meeting of both irrigators and town officials to discuss possible solutions to a mutual problem of dwindling water supplies. In response to advertisements and mailings, the turnout at the January 2009 meeting included an estimated 70 percent of irrigators. (Commission 2008) p 18 (Commission 2008)(Lidstone March 2009)(Lidstone 2009)

The mayor of the town was concerned that the meeting would demonstrate a division between irrigators and the town. His fears indicate there has occasionally been such a rift. The mayor himself had been an irrigator but not in the Pine Bluffs area: he moved to Pine Bluffs to "live in town" on retirement, choosing Pine Bluffs rather than a tiny settlement closer to his farm or the capitol city some 40 miles away.. (Anderson March 2009) (Lidstone 2009) That choice, which apparently others have made, indicates the ties between farmers and town, since the town offers a place older farmers can live when they can't continue to work the farm.

At the January 2009 meeting, there was a noticeable rift, but it was not between townspeople and farmers. It was between large and small farmers. Initially, all attending agreed that all the irrigators were generally experiencing declining water supplies in their wells. However, one member of the upcoming generation (age 30-40) now taking over operations in a very prosperous farm family (one branch of the family also owns the bank in town) stated that in the face of water supply declines each farmer should and could deal with the situation on his own. Each should continue to assess what he believed his well and soils could do in the coming year, and act accordingly, rather than take collective action, this young man asserted. By contrast, another man of about the same age with a small place of his own pushed for an attempt at collective action.(Discussion 2009)

Both historical records and discussion after the meeting indicate that there has been a longstanding divide or boundary between large and small farmers, and that this divide may be a major obstacle to any attempt at collective action to deal with water supply depletion in the Pine Bluffs area.

In 1946, when establishment of a system of statewide governance for groundwater was first being considered in Wyoming, it will be remembered that it was in Pine Bluffs that some of the most vocal opposition developed to the idea of bringing groundwater under the governance scheme that applied to surface water. In 1946, a member of a prominent Pine Bluffs farm family spoke up against any form of groundwater governance. He was from the same family as the “each to his own” speaker at the January 2009 meeting. In 1946, that family already had large farms and ownership of the local bank. (Sundin 2009) It was the member of this family who stated that in his view groundwater belongs to the people who own the farms (and therefore they did not need any community or public authorization to use the water). He opposed any legislation that could bring on governance of groundwater.(Lloyd 1946) (p. 1)

Interviews after the January 2009 meeting made it clear that local people recognize a long-standing boundary between large and small farmers in the area. A member of the state Legislature who is a Pine Bluffs area farmer characterized statements against collective action at the January meeting as typifying a familiar attitude in the area that “the guy with the biggest checkbook will be the last man standing.” (Anderson March 2009) A woman who manages a small farm with her husband and had spoken up for the need for collective action said that no one in the Pine Bluffs area would believe that any real community solution would be forthcoming or effective unless the large farmers agreed to “sacrifice” like small farmers, as part of the solution. (Sundin 2009)

The presence of enough social capital to take collective action has varied in the Pine Bluffs area in the past. Two community efforts affecting town resources important to farm families have been successful in the past. First, area residents mobilized to protect of the town’s old high school building from demolition

reportedly advocated by “newcomers” to the area (the building now houses classes offered by a community college based 40 miles away). Second, residents managed to ensure a new library building was constructed in the old town center rather than on the edge of town near a major highway. The woman small farmer who spoke of the need for larger farmers to sacrifice led the library effort – against opposition from the banker branch of the larger farm family. (Sundin 2009)

In 2003, a state agency charged with rural economic development hosted discussions and recommendations of other measures to reinvigorate the entire Pine Blulffs community. Recommendations included programs to engage the energies of high school students in town clean-up and restoration, and efforts to attract a movie theater or a pharmacy to the town.(Rural Development Council 2003) pp 12, 20, 22. By 2007, however, no successful follow-up efforts on those recommendations had occurred.(Rural Development Council 2007) p. 27 This contrasts with successful follow-up efforts that occurred in other Wyoming towns. At the 2003 discussions themselves, state facilitators noted that attendance and participation was low. (Rural Development Council 2003, p. 16) Though state agency team members noted community pride in Pine Bluffs, the scarcity of action since 2003 may indicate some scarcity of the kind of social capital that could be necessary to take collective action on community issues.

On the other hand, there seems to be a persistent spark of interest in local collective action, particularly where water is concerned. In 1946, the same member of the prominent farm family who opposed putting groundwater under the familiar statewide water governance system did leave an opening for *local* collective action. He “suggested the formation of an association of farmers to handle any overdevelopment and the general situation.” (He also implied there would be no need for such a farmers’ association – wrongly predicting that not many more irrigation wells would be drilled in the area in any case.) (Lloyd 1946, p. 2)

The January 2009 meeting speaker from the same family, interestingly, struck the same note. He expressed distrust of water governance via the state governance agency, decried as unwanted “regulation” - but he was interested in possible local collective action. At the end of January 2009 meeting, he volunteered to serve on an ad-hoc committee to explore collective action, despite his statements during the meeting disparaging the idea that collective action to address water declines could be useful. (Discussion, 2009)

Where groundwater is concerned, all the farmers around Pine Bluffs acknowledged in the January meeting they are highly dependent on it. They also are dependent on high levels of technology to access and use it. Almost all irrigation in the area is from wells and via sprinklers.

Professional reports and discussion at the January 2009 meeting made it clear that the farmers have, however, little knowledge of the socio-ecological system in which they play a part. This is partly due to the peculiarities of the aquifer involved, but also due to lack of investment in acquiring and collating information about the system. The chief geological consultant who has studied the area said he would “love” to have information he does not have – data on how much water the aquifer can safely supply to users on an annual basis. Even data on the total amount of water irrigators now use is lacking. Considerable time was spent at the January 2009 meeting discussing how to obtain data on current usage, as well as aquifer yield. (Dahlgren Consulting, Engineers 2001) (Lidstone 1995) (Discussion 2009)

3. Interactions and outcomes

3.1 Historic and present

For over a hundred years, interactions among these users and between them and the water resource system available to them have been one-directional - users have tapped the water resource without learning much about it or making serious attempts to make its use sustainable. The outcomes have become increasingly poor.

Users harvest the water individually as best they can, with whatever level of technology (to reach the water, pump it, and convey it to crops) they can afford. Though no records of per-user pumping are publicly available, it is clear that harvesting of the groundwater varies greatly among diverse users. It is therefore possible that the more prosperous farmers harvest more water, per acre of crop. Of course, the idiosyncrasies of the aquifer could mean that a farmer with poor finances might end up with the best water supply, even if tapping the groundwater with mediocre technology. Faced with poor water production, however, farmers with money have more options to buy other land, drill new or deeper wells, install more efficient pumps, and get water to more crops more efficiently. The advantage that money has historically provided in helping large farmers deal with the peculiarities of the local aquifer is probably one reason the small farmer quoted above believes that large farmer “sacrifice” is a prerequisite for collective action to manage dwindling water supplies for the benefit of all in the Pine Bluffs area.

The irregular groundwater supply and the unequal capacity for dealing with its irregularity also appear to foster mutual suspicion among users. Distrust is made even more likely by the failure of users to share water information with each other on any regular basis. With no use records available, no one can really be sure how other wells are performing. There is always room, however, to believe that someone else’s water harvest is better than yours - and possibly draining yours. Nonetheless, farmers keep investing their labor and their funds into their

operations, even as water supplies dwindle, perhaps because they don't see another option. It is as if all the farmers are chained to a grinding mill wheel.

In 1971, Pine Bluffs users did request the central water governing agency to establish a "control area," as allowed for groundwater under the governance statute approved statewide about 15 years earlier. Landowners voted for representatives on the advisory board for their control area. The votes, however, were weighted according to statute in a way not likely to reduce the large-small farmer rift and accompanying distrust in the area. The statute provides that those with the most acres cast the most votes in a control area election. Wyoming Statutes Annotated (WSA), 41-3-913 (c) (The model may come from that of irrigation districts, designed to fund and manage irrigation works by assessing per-acre fees. In that case, per-acre voting power for members might arguably make sense. Where, however, the goal of an institution is to manage a scarce resource, possibly through use restrictions, the wholesale importation of the irrigation district model for control area advisory board elections, giving more voting power to those who have the most farmland, does not seem wise.

Once instituted by the statewide water governance agency, with its advisory board elected by local landowners, the Pine Bluffs Control Area neither addressed the lack of information and understanding of the water resource system nor came up with a plan for "control" of the resource system for the benefit of all users.

The statewide governance agency did undertake "adjudication" of all existing wells: measurement of production from each well and verification that the water produced was being used without waste to produce crops. That was required by the statute. The agency did not attempt to determine the "safe yield" of the Brule aquifer, and the advisory board elected by landowners did not ask for a study to determine safe yield. That was optional under the statute. The agency did, however, in 1972 provide the advisory board with the results of a new study that documented steadily declining yields via measurements in key wells. (Minutes 1971-1981) (9-1-1972 meeting, p. 3)

Detailed continued monitoring of the resource, however, apparently did not occur. Reports from such monitoring could have provided users and the advisory board with a growing understanding of their water resource. It also might have tipped them off early on to a problem that could have been addressed. At the time, increased efficiency in water use via mechanized irrigation was encouraged by federal and state funding agencies and by academics advising farmers. Since then, however, it appears that the move to mechanized sprinkler systems had an unanticipated impact on the resource. The sprinklers appear to have deprived the White River formation around Pine Bluffs of recharge water once provided by flood irrigation of the fields. Accordingly depletion of the aquifer has probably accelerated with increased investment in mechanized sprinklers. (Lidstone 2009).

Minutes of the Pine Bluffs Control Area Advisory Board meetings that began in 1971 show the advisory board did not recommend a groundwater management plan for the area for state governance agency approval. The statute specifically contemplated an advisory board or simply groups of landowners in a control area pushing for groundwater management in that way. A national expert on groundwater in the 1950s had recommended the formation of local groundwater districts specifically to foster what he called “community action” in groundwater management. The Wyoming statute of 1957 apparently tried to follow that recommendation.

The invitation to “community action” offered by the statute has never been taken up, however. The governance agency urged the Pine Bluffs advisory board to recommend a management plan, on several occasions. (1971-1981 minutes: 9-1-1972, p. 2) The minutes show the advisory board work sometimes approached creation of a management plan, but never actually produced a plan. (1971-1981 minutes: 12-7-1972, p. 3) Agency staff believe that the advisory board would come to the brink of pushing for a management plan and then back off, with hopes that “maybe it will rain.”(Harju 2009)

What the Pine Bluffs advisory board did do was review individual applications for new groundwater wells, hold hearings on some well proposals, and make recommendations to the statewide governance agency as to whether permits for those wells should be granted. The board did not, of course, have the detailed information about the capacity and behavior of the aquifer involved that would allow assessment of individual new well proposals in the context of the pressures on the entire aquifer. The minutes suggest that sometimes the governance agency followed the local advisory board recommendations, and sometimes not. (1971-81 minutes)

The minutes make it clear that the advisory board’s main function was as a forum for discussion of local development and governance agency policy, and a source of feedback for the agency. The advisory board did not take on any governance role. Probably it could have done so - by requesting more studies and monitoring, and designing and proposing a management plan.

Ten years after the Pine Bluffs Control Area was formed, it was absorbed into a new, larger entity covering about half the county where Pine Bluffs and other groundwater-dependent farming areas were located. From 1981, Pine Bluffs water users typically elected only one of the five members of the advisory board of the new Laramie County Control Area. That board continued primarily to discuss and make recommendations on permits for individual wells, and did not propose comprehensive management. (Office 2005)

Steady declines in groundwater levels were clearly attributed to irrigated farms in the 1972 study presented to the control area advisory board soon after its

formation. (The 1972 study reported that measurements showed water levels had dropped since 1961 though precipitation had not changed in the previous ten years). (Dahlgren, 2001, p. II-7). Water levels have continued to drop 40 years later, (Dahlgren 2001, p. V-1) Clearly there has been over-harvesting, and the system now has reduced resilience. Use of the diminishing resource meanwhile lacks efficiency, equity and accountability, as users' mutual distrust indicates.

3.2 Possible future interactions and outcomes

The groundwater users around Pine Bluffs appear to have two options for the way they interact with each other and their water resource system in the future.

First, they can keep operating as they are, each on his own – till one man is the "last man standing." To reach that point, family after family will have left their farms, bowing to a combination of declining water supplies and economics that will make it impossible for some to keep on farming. Some may have the finances to drill deeper wells or acquire farms with better-producing wells. Perhaps as the water supply situation gets more desperate, someone will call on the statewide governance agency to regulate groundwater use by giving the highest priority to those with the earliest date of groundwater use. That might have a final impact on who is the "last man standing," but it seems unlikely to prevent the extinction of the larger farming community in the area. Clearly, though, the current problem will ultimately be resolved by a combination of geology and economics that thins out the farmer population, and perhaps ultimately eliminates irrigated agriculture altogether in the area, if the farmers take no action together.

Second, the irrigators could create their own new institution for governing groundwater. This would require creating a functioning group that included equitable representation for all the farmers who chose to be involved. If that could be accomplished, though, they could gather and share information about each other's water uses, and begin to work together for change in use patterns.

Such plans for water use and governance could be undertaken under existing state law. As discussed above, the statutes on groundwater specifically provide that in the special case of control areas, a group of users can come up with their own plan for water usage that might involve sharing, rotating, reducing uses, etc – and such a plan can be enforced by the state if it receives the blessing of the top state water governance officer. (WSA 41-3-915c) At the January 2009 meeting, that top official attended, expressed strong support for Pine Bluffs area users coming up with a plan, and suggested his eagerness to endorse such a plan. (MacKinnon, 2009)

3.3 Indications of potential for future collective action

At the January 2009 meeting, a smattering of people volunteered to work as a smaller committee on a draft plan of action. Members of both the large and small farmer group volunteered for the committee – after some nudging from outsiders leading the meeting. In February, the person who had agreed to pull this small group together reported the group wanted first to meet without any outsiders present. No small group meeting had, however, occurred as the calendar moved into April, nearing a time when farmers would be too busy in the fields to meet.

From January on, however, there were some signs indicating collective action could occur and have positive results.

One positive sign in January was discussion of ways to generate better information about the aquifer and its use. One of the prerequisites for effective collective action in natural resource management is a shared understanding of the resource.(Ostrom 1990; Ostrom 2005) This is particularly true in groundwater, where resource characteristics are by definition hidden and hard to discover. Residents of a number of groundwater basins that have put together effective local management systems have made comprehensive studies of resource capacity and stresses a key step to help bring their communities together for action. Considerable investment in the creation of such knowledge is often necessary and helps bring communities together as well. (Blomquist 1992, pp. 7, 77-78, 91-92, 120, 152, 180-181, 211, 240-241, 267-68, 290)

At the January meeting in Pine Bluffs, there was considerable discussion of a management strategy designed expressly to create a better understanding of the aquifer. The discussion focused on a proposal to experiment with a percentage reduction in all water use, and an increase in monitoring to see the results and thereby help characterize the aquifer.

Professionals say there remains much unknown about the White River Aquifer, including its safe yield and its recharge capacity. Users and professionals also know very little about the production history of each other's individual wells, a history that could help fill in the picture of how and why the aquifer yields water unevenly. (Lidstone 2009; Discussion 2009)

Obtaining more information about the aquifer may not be a matter of finding funding for a detailed study. Discussion at the January 2009 meeting did explore the idea of seeking a state-funded aquifer study. In fact, such a study appeared to be reasonably easy to obtain, because of the potential interest of the Wyoming Water Development Commission, which had called the January meeting. The program overseen by that commission is well funded by taxes on energy minerals production (oil, gas and coal).

Such studies have provided the crucial basis for successful local water management efforts in other groundwater basins. (Blomquist 1992) , op cit. But they may not be as valuable in the Pine Bluffs situation. The key groundwater

geologist familiar with the White River aquifer underlying Pine Bluffs suggested that such a study, both expensive and time-consuming, might not be helpful. Because of the nature of the aquifer, a new study might yield less information than a carefully planned use-reduction experiment taken on by the irrigators, the geologist suggested. Use-reduction efforts in certain locations, accompanied by monitoring and by water supply and use information from all wells in the area, could produce the most valuable data about the aquifer, he said. (Discussion 2009) He was essentially proposing an adaptive management scheme that could allow a continuous feedback of information to inform and shape new management efforts, an approach that has proved helpful in managing the socio-ecological systems involving water in other locations.

Increased experience and information has already had some impact on farmer interest in collective action. At the January 2009 meeting of Pine Bluffs townspeople and irrigators, a long-time legislator from the area spoke up in favor of collective action to create a local management plan for groundwater. Interestingly, he had also been in the 1970s the chairman of the control area advisory group that chose not to pursue any plan for reducing groundwater use in the area. (1971-1981 Minutes). In a discussion after the meeting, he said that increased information that had made him change his mind over the period from 1980 to 2009 – some 30 years. Loss of water in key wells, in fact, had forced him to sell part of his family's farm recently - that was information he could not ignore. (Anderson, 2009)

This local leader's additional comments also exemplify what could happen to bridge the traditional divide in this community between larger and smaller farmers. The loss or threatened loss of a farm, due to lack of water, clearly resonate with local farmers of any size, and can spur new thinking and new action.

"It's very hard to leave your ranch, to sell it ... Farm people are different from oilfield people. When you've *lived* on a place...," this farmer said, stopping as tears came to his eyes, when discussing potential follow-up to the January meeting, two months later. (Anderson, R.P., 2009)[‡]

Possibly other members of the more prosperous farm families will begin to see their own self-interest in taking collective action – if they have sufficient problems with their own water supply. Further, the involvement of some of them in town businesses, including banking, may help them to see their own interest in collective action. A winnowing out of farm families unable to stay in operation presumably would ultimately be detrimental to the local bank and other town businesses.

[‡] The contrast between farming/ranching and the oil industry comes naturally to a Wyoming speaker in a state where the energy industry – oil, gas, and coal production - dominates the economy and the state's revenue picture.

Incentives to make collective action worthwhile for its participants are always necessary (Ostrom 2005). At the January meeting, an economist from the University of Wyoming emphasized the need for incentives to make collective action in groundwater management worthwhile for the farmers.

First, the economist supported the geologist's idea of an experimental approach to managing and generating information about the aquifer. She suggested that the money required for a professional study might instead be better spent on the locally-designed adaptive management approach, and incentives. Funds could not only design and monitor experimental cutbacks, but could pay for an innovation in the area, she suggested: perhaps paying for temporary piping to help move water from a farm with a good well to one with a failing well. (Discussion 2009)

Her idea was to create a local market in water use that would give larger farmers with ready cash an incentive to join and design a local water management plan. In other parts of the U.S., when water use cutbacks are proposed, there are also means set up for users with cash to pay for using more water than the cutback would allow, by paying a neighbor to use less. The group's water use remains at the cutback level, but individual farmers are able to use more if they can pay for it and find a seller willing to use still less than the cutback requires. (Blomquist 1992, op cit) Due to the idiosyncracies of the White River aquifer, it might not be practical for one neighbor simply to pay another for water and plan to pump that extra water up out of the aquifer from his own well. Water might not be available there. But the university economist suggested that proper funding might help buy a system of temporary piping to facilitate temporary purchases of additional water use. One of her university students has since January been exploring the costs and feasibility of a piping scheme. (Law 2009)

There was another indication in January that other members of the group of large farmers may already have information that makes them appreciate the value of collective action. Some who were publicly skeptical nonetheless in the end volunteered for a core committee to work towards new water management.

Finally, another positive note was that staff working for a different county-wide elected board authorized to focus on resource conservation followed up on the January meeting by proposing a new strategy. The Laramie County Conservation District staff worked quickly to draft a proposal to identify and pay for the voluntary closing down of perhaps 35 large producing wells in the Pine Bluffs area. They planned to submit that proposal to the federal government for funding in April. (Cochran 2009) Such a program could complement a strategy of across-the-board reductions in water use at wells that continue to operate (as discussed at the meeting). The conservation district proposal already has the initial support of key larger farmers. (Blaine 2009). Meanwhile the farmer who is a legislator is also considering seeking state funding for such a well-purchase/shut-down proposal, to allow it the option to be offered to more area farmers. He suggested

that a number of farmers in the area could be convinced by such a program to return to dry-land farming, practiced in the area nearly 100 years ago. (Anderson, P. 2009) The conservation district proposal includes funding to help create watering sites for livestock to accompany a switch to dryland farming. (Cochran, 2009)

Another factor that could encourage local commitment to collective action would be increased understanding of the local implications of climate change. Unfortunately, work is only just beginning to localize large-scale climate models in order to predict local impacts, and polling thus far shows that in popular understanding in the Western U.S. there is little connection made between climate change and water supply problems. Despite recent experience, especially dry years are considered "natural" rather than an indication of climate change. (Environment 2008; Project 2009))

Already a semi-arid area, the Pine Bluffs region has shared in what people in the region have called the "drought" of nearly the last decade. Although the dry conditions have lessened somewhat, figures still show precipitation of only some 80-90 percent of normal for the Pine Bluffs area in the last two years. (Council 2008; System 2009; System 2009) That makes farmers more dependent on groundwater – and potentially more painfully aware of what declining groundwater can mean. Of course, it could also make farmers more wary of shifting back to "dry farming" under new, potentially drier conditions. It might then make them more despondent of any benefit from collective action. Only the results of detailed modeling of local climate change impacts (not yet undertaken for this region) can suggest how understanding of climate change will ultimately affect collective action efforts in Pine Bluffs.

4. Analysis and conclusion

The intensive use of groundwater in far southeast Wyoming has created a farming community that may now become unsustainable unless the community itself takes on the job of making changes.

The community established itself on lands that could support farms producing relatively low-value crops only with the help of irrigation. The community came to be an atomized one. Perhaps that reflected the fact that the key resource they used hid their impacts on each other, even as they all increasingly relied upon it. The community also became characterized by a rift that is probably common to many small farming communities – between those who became relatively prosperous through a combination of luck, hard work, and early connections with other sources of income, and those who kept on with a more marginal economic existence.

After some 70 years of increasing use of its groundwater resource, an institution was created specifically to govern use of that resource in the area, but the

institution only exacerbated existing problems rather than helped to solve them. Imposed from above (by a central state water governance agency), the local "control area" was endowed with a "board" of locals who had only advisory power. In addition, the people serving on the advisory board were elected under a system giving the most voting power to the owners of the most farm acreage, thus entrenching the rift already tending to split the community. There was no substantive move to self-governance in the arena of local groundwater supplies, and no experience of self-governance. The result of this governance system was continued decline of the groundwater resource.

The contrast between this system and its result, and the management of surface water in the same area, is instructive. Surface water management in Wyoming is much more effective, and operates through a more nested system. What has led the same society to come up with effective management for one water resource and ineffective management for another? The groundwater resource is of course much more difficult to understand; concern for governance of it arose in a later period of development of Wyoming society; and dependence on groundwater that might be dwindling was isolated to only a few parts of that society. Those are all different from the circumstances which led to the growth of an effective surface water governance system in Wyoming. They are not, however, very different from the circumstances surrounding groundwater in California, where local communities did create more nested and effective governance systems. The difference between Pine Bluffs and California, however, is that those dependent on groundwater were a significant part of California's society and economy – and the results of depletion in their groundwater basins led to a sense of urgency, of crisis, which led them to come up with new, local institutions. It appears that the farmers around Pine Bluffs have accepted and even preferred a centralized, flat system of governance, to the local and perhaps nested system they could have created (and were invited to create), because they lacked that sense of urgency. They lacked it until now – or key players in the community may still lack it.

In Pine Bluffs, water supply declines have finally reached the point where the small town in the center of this area has sought financial help from a state water development agency. That action, in turn, caused the state development agency to call a meeting of townspeople and irrigators. At that well-attended meeting, all present acknowledged a general water supply decline. They also recognized that a potential solution could lie in collective action to create a new, local institution to generate a water use management plan, with the blessing of the centralized state water governance agency.

A key component is missing, however. The larger farmers need to have information that makes them commit to collective action and help create a new institution to govern local water use. Specifically, they need information that would convince them that they themselves will suffer if groundwater around Pine Bluffs is not managed for the benefit of all.

Working together, the large and small farmers could create a local institution which equitably represents them all and which could devise an adaptive management plan to experiment with aquifer use in order to both slow down depletion and learn more about the resource. Existing law affecting Pine Bluffs would allow this. An experimental approach to generating information about the aquifer would give the farmers experience in beginning to work together to manage their water supply, rather than continuing to put off that effort. In the process, farmers could acquire a better understanding of the aquifer, its depletion problems, and its possible physical routes to stabilization or recovery – all of which will be crucial to the design of governance effective long-term. Such an approach to generating the needed information was discussed at the meeting of townspeople and irrigators.

As part of an experimental, adaptive management effort, a new local governance institution for groundwater could for instance: arrange offers to buy out heavy-use wells and shut them down; reduce uses by a certain percentage; monitor impacts on the aquifer; and/or allow water use to be shifted from one user to another by allowing one user to increase use by buying out another user for a year. Due to the vagaries of the aquifer involved, that could require use of temporary piping to move water to a different location for use. And, finally, the local institution could help farmers jointly consider returning to dry farming or farming with much more limited irrigation. That could mean seeking financial aid from the larger community around them (including the state government) to help in the many transitions necessary for dry farming to once again take hold. The local institution could also serve as a center to request technical agencies (state and federal) to develop information on local impacts of climate change, and transmit that information to the farmers

Whether however the Pine Bluffs farmers will take a collective action route to address their mutual problem of groundwater declines remains to be seen. The community in the past has demonstrated only a mild amount of the social capital that could be required in order to pull itself together now for major collective action on a potentially-divisive resource management issue. Yet initial community action now could be the step needed to generate the kind of information about the resource likely to spur the community to take genuine collective action for the first time. Taking that first step will require crossing the boundary between the more-prosperous and less-prosperous farmers, a boundary which appears to have marked a significant rift in this community over a number of decades. It will require that the prosperous farmers recognize that they have something in common with their less prosperous neighbors. They may all need a new approach to groundwater declines. A smattering of signs indicate that the prosperous farmers may be coming to that realization.

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