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Chapter 17

Polycentric governance in Nebraska, U.S., for ground and surface water

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ABSTRACT

This chapter describes the locally driven, but centrally coordinated, water governance model in Nebraska, U.S. It offers a snapshot of water resources and the importance of agriculture, then moves to the relevant political institutions in the state, and federal controls related to water quantity. The focus of the chapter is on the Nebraska Department of Natural Resources' (NeDNR) and Natural Resources Districts' (NRDs) management of surface and groundwater, which has some distinct and some overlapping authority. The main area of overlap is in addressing the connection between ground and surface water, particularly in situations when either or both are over appropriated. Integrated management planning is a key tool for basins in crisis, where allocations are fully or over appropriated and there is increased demand or diminished supply. The chapter explains what integrated management planning entails and gives a closer look into instances where it has been implemented. The polycentric model allows for collaborative governance, pushing stakeholders (particularly the agricultural sector) to innovate based on changes in water availability. NRDs can (and do) exercise controls; they do so by using their authority to make institutional changes and sanction violators for over-abstraction. This authority is granted and legitimized by publicly elected boards, an ongoing leadership training network, and a history of locally driven rule-making. However, there are also shortcomings to the model: in particular, it is difficult to address cross-border issues or legal conflicts. Furthermore, there is scant research on its effectiveness in actually preventing groundwater decline. The Nebraska model and its local examples may offer lessons for other basins where water resources have historically been relatively plentiful but are now facing drought stresses and the growing demands of intensive irrigated agricultural production.

Keywords: Drought, federalism, governance, groundwater, integrated water resources management, Nebraska, polycentricity, surface water, United States

17.1 INTRODUCTION

The authority to make decisions about water allocations in Nebraska is distributed across local, regional, state, and federal institutions. At the center of Nebraska's polycentric water governance is the working relationship between sub-state entities called Natural Resources Districts (NRDs) and the state's natural resource agency, the Nebraska Department of Natural Resources (NeDNR).

Generally speaking, surface water is administered by the NeDNR and groundwater is governed by NRDs. While other states use local resource planning units to manage water, the NRD model does not exist in any other state and is unique in its scope of responsibilities for managing the hydrological connections between ground and surface water when maximum allocations have already been issued. This interplay of political authority is an instance of polycentric governance.

Polycentricity is a condition in which decisions are made by multiple distinct but overlapping centers of authority (Ostrom, 2010) and is often applied to environmental governance due to the complex, multi-dimensional, and diverse range of resources subject to overuse or depletion (Carlisle & Gruby, 2017). This framework is fitting for analyzing Nebraska's water governance because of the diversity of actors and levels of decision-making. The need for this mix of authority stems from the fact that there is an abundance of irrigated agricultural production in the state, which has historically thrived. However, in recent decades, some areas of the state now face water stress. Groundwater gives a buffer against variable surface water availability, especially during droughts. Among U.S. states, Nebraska has the most irrigated cropland and pastures (Bleed & Babbitt, 2015) with 8–9 million acres of farmland under irrigation, 32% of the state's total area (U.S. Department of Agriculture, 2019). Most irrigation is supplied by groundwater from the Northern High Plains (Ogallala) Aquifer. Groundwater in the northern region of the aquifer is being withdrawn at a higher rate than it is being recharged. Almost half of the loss in 2000–2009 occurred in the Republican River Basin, which is shared between Colorado, Nebraska, and Kansas. These losses are due to irrigation withdrawal, driven by decreased rainfall and increased surface water evaporation (Peterson *et al.*, 2020).

Nebraska is a state of stark ecological contrasts, which influence the diversity of agricultural production. About a quarter of the state is a Sandhills ecotype with high soil erosion and low precipitation (Dalstrom & Naugle, 2020). These areas are used more for cattle grazing than crop production. In the rest of the state, however, prairie and humus soils are suitable for small grain production (Ibid). The state receives variable annual rainfall with the yearly statewide average ranging from 13.36 inches in 2012 to 35.50 inches in 1915 (Frankson *et al.*, 2017). The average annual rainfall also varies geographically. The eastern portion of the state receives about twice as much rain (35 inches) as the western part (15 inches) (Shulski, 2018). Because of drought, irrigation is a major dimension of agriculture in Nebraska (Ulrich, 2018), and has led to increased yields and an increase in property value. In recent decades, droughts plagued the state from February 2002 to September 2008 and again at a peak the first week of October 2012 with more than 77% of the state in severe drought (National Drought Mitigation Center, 2021). Without groundwater irrigation, the state's agriculture-heavy economy would suffer more than it already does during droughts.

Agriculture dominates Nebraska's water consumption (6100 Mgal/day, U.S.G.S., 2021a), and the state is still experiencing a boom in irrigation. Roughly 300 000 acres were added between 2007 and 2017, while another 440 000 acres were added between 2017 and 2020, reaching a total of 9.03 million acres of irrigated land, mostly from groundwater (Nebraska Association of Resources Districts, 2021). In 2015, usage rates were 5400 Mgal/day for groundwater irrigation and 673 Mgal/day for surface water irrigation (U.S.G.S., 2021a). In contrast, the public consumes 1720 Mgal/day and thermoelectric power generation requires an average of 2900 Mgal/day (U.S.G.S., 2021a).

To date, groundwater supply and access have been relatively stable in Nebraska, even during drought years. The state sits on one of the world's biggest reserves of groundwater, the High Plains Aquifer, which is approximately 174 000 square miles (Johnson *et al.*, 2011). The formation lies beneath the jurisdiction of eight U.S. states and is estimated to hold 2.91 billion (10^9) acre-feet of water. Nebraska holds 65% of the volume (Peck, 2007). Some irrigators, however, do not have easy access to groundwater (Peck, 2007), and in recent years there has been a decline in aquifer volume (U.S.G.S., 2021b). The remainder of the state's needs, then, are supplied by surface water diversions, the two major rivers being the Platte complex (North and South) and the Missouri.

17.2 FEDERAL CONTROLS ON WATER ALLOCATION

The responsibility for governing water quantity resources largely lies with states and sub-state actors in the U.S., who carry out the majority of water delivery and wastewater removal (Stoutenborough & Vedlitz, 2014), though federal responsibilities include providing drought-related economic relief to famers or building new dams and managing reservoirs. Furthermore, some federal obligations explicitly or effectively limit Nebraska's authority.

For example, there are two sources of federal-level resource allocation that apply to the Platte River and Republican River basins, respectively. On the Republican River, Nebraska is a party to an interstate compact with neighboring states, Colorado and Kansas. These interstate agreements are approved by Congress and carry the imprimatur of federal law, displacing state law or actions to the contrary under the U.S. Constitution's Commerce Clause. The Republican River Compact caps the yearly amount of the river's 'virgin water supply' Nebraskans can consume. States are responsible for the Republican River Compact Administration[1]. The Compact limits surface-water diversion and groundwater use that depletes streamflow. It has been one of the key drivers of integrated resource management in the Republican basin (Aiken, 2008).

The second federal restraint occurs through the Endangered Species Act protection of the whooping crane, piping plover, interior least tern, and the pallid sturgeon (Jenkins, 1999). The obligation to protect habitat for these bird and fish species has required Nebraska to reduce its consumption of water in the western two-thirds of the Platte River Basin. Because this habitat is riparian, all activities that deplete streamflow are impacted, including direct diversion of streamflow or indirect diversions through groundwater pumping. This has been a key driver of Nebraska's effort to integrate its water management, effectively limiting consumption during drought. Even within these federal restraints, however, states still wield a great deal of authority over water management. As the Western Governors' Association (2018) claims, states are the 'preeminent authority on water management within their boundaries', with rights to surface water and groundwater management.

17.3 STATE INSTITUTIONS FOR MANAGING WATER ALLOCATIONS

Nebraska is governed by a unicameral legislature seated in Lincoln. The governor presides over most[2] administrative agencies, including the NeDNR by appointing its director. The legislative role in administrative operations is also strong as agencies may not do anything that is not allowed by statute. The NeDNR is a state-level agency, directed by an unelected director who manages a professional staff, carrying out operations under statutory directives and pursuant to regulations adopted under formalized statutory procedures. Its budget is determined through the state appropriation and budgeting process, and its revenue comes from sales and income taxes.

17.3.1 Surface water administration

For present purposes, the NeDNR's main role is administering surface-water rights. These are allocated under 'prior appropriation'; users with historical rights have priority claim to the water. This is different to a riparian rights system which automatically allows property owners along a river, stream, or water body to make diversions. During shortages, riparian systems may allocate water to multiple users equitably, without regard to the date of one's first diversion or any similar vesting of rights. The prior-appropriation system of allocation, predominant in the western U.S, abandons these uncertain outcomes in favor of a system that creates predictable water supplies according to a somewhat strict system of temporal priority. This, in turn, spurs investments in the infrastructure necessary to deliver water to users.

[1]For more information, see the Compact website: http://republicanriver.org/

[2]The Governor has direct control over Code Agencies (e.g., NeDNR) but not Non-code Agencies (e.g., Game and Parks Commission)

Surface appropriations are generally granted for a right to divert water for an authorized beneficial use. If granted, the right's priority dates from the time of application[3]. The system also involves an administrative mechanism for changing or transferring appropriations after they are granted. Transfers are allowed when the original holder files to change the location of use (Nebraska Administrative Code, 2008). The nature of use or the holders of surface-water rights can also be changed through an administrative review process initiated by an appropriator. In addition, appropriations that are not used can be canceled by the NeDNR. In this sense, surface-water rights are often thought of as 'use it or lose it' rights (Ibid).

17.3.2 Groundwater administration

Groundwater appropriation is significantly different, largely due to the NRD institutional structure. State law specifies that NRDs are the 'preferred regulators of activities which may contribute to groundwater depletion' (Neb. Rev. Stat. § 46-702 in Nebraska Association of Natural Resources Districts, 2021). They are local governments with geographic boundaries that correspond with a combination of watershed boundaries and county line administrative units. The boundaries were collaboratively determined in expert hearings on the extent of 'common problem areas'. NRDs' borders resemble a blend of areas that, in former times, were used as Soil Conservation Service districts, Bureau of Reclamation districts, Corps of Engineers drainage districts, Conservation and Survey Division groundwater districts, and Farmers Home Administration water supply districts (Fairchild, 1994). Every watershed in the state has more than one NRD within it. For example, the Republican River Basin has four NRDs with mutually exclusive boundaries (the Upper Republican NRD, the Middle Republican NRD, the Lower Republican NRD, and the Tri-Basin NRD).

An elected Board of Directors governs NRDs. Voting districts comply with a one-person-one-vote legal requirement, so each district has a similar proportion of the district's voters within it. Property and occupation taxes on land's irrigation status are primary sources of revenue. While the publicly elected Boards of Directors govern the district's operations, NRD tasks are carried out with professional staff, including a General Manager who has general administrative oversight. Together, the directors, management and staff work with members of the public and landowners to make decisions about water allocation and drought contingency plans (Nebraska Association of Natural Resources Districts, 2019).

Since Nebraska's water availability varies greatly by location, so do priorities and approaches to management. An area's elevation, climate, groundwater supplies, surface water storage capacity, anthropogenic demand for water, along with underlying environmental, social, economic, cultural, and physical factors influence how susceptible a location is to drought (Hagenlocher *et al.*, 2019). Additionally, the history of cooperation varies between NRDs, with some having engaged in more extensive water-related planning than others.

NRDs manage groundwater against the backdrop of a common-law right to withdraw water from beneath one's property. These correlative rights did not require a permit for their existence, and they could not be lost through the passage of time. As scarcity problems emerged, though, NRDs were given statutory authority to regulate withdrawals. Historically, NRDs did not use this authority very often. In 1980, only one NRD imposed limits on groundwater withdrawal (the Upper Republican). But as connections between ground and surface waters were better understood, NRDs became active water regulators.

17.3.3 Water law and legal conflicts between ground and surface water users

Understanding the development of Nebraska's water law in the context of the conflicts that drove its modification is essential to understanding the present institutional polycentricity. While surface-water rights have generally not existed in Nebraska in the absence of statutory law, groundwater rights were first enunciated in common-law litigation initiated by adjacent landowners. Landowners held the right to withdraw and use water from beneath their properties. As water use began to impact

[3]https://dnr.nebraska.gov/water-admin/faqs#sw-permit

neighbors (due to declining water tables), litigation led to limitations on water use. Generally, these rules allowed landowners to use water on their property for 'reasonable' uses, and, in the event of conflict resulting from a shortage of aquifer supply, the common law requires each landowner to share the burden of reduced use correlatively. These landowner rights still exist to some extent today but, as demonstrated below, they have been largely modified through statutes that empower NRDs to manage water.

Those modifications arose through legislation adopted in the 1970s and 1980s, which allowed NRDs to create Water Management Areas and prescribe controls that would avoid well interference. Well registration and spacing requirements were the main forms of control adopted in this era as groundwater shortages became common in some parts of the state. Within those restraints, the water supply decline was a foreseeable and largely accepted consequence of groundwater pumping (Peck, 2007)[4].

Prior efforts at groundwater regulation proved insufficient to avoid conflicts between groundwater pumping and surface water rights. Drought years placed intense strain on the system, and legal action instigated by surface water users against groundwater irrigators within Nebraska (e.g., *Spear T. Ranch, Inc v. Knaub, 2005*) and by adjacent states (*Kansas v. Nebraska and Colorado*) ensued. In *Spear T.*, the Nebraska Supreme Court first recognized a cause of action against groundwater pumpers that could be pursued by surface water diverters, with liability occurring when the pumping of hydrologically connected groundwater unreasonably interferes with surface water appropriations.

In the case of *Kansas v. Nebraska and Colorado*, Kansas was awarded $3.7 million for surface water that the U.S. Supreme Court ruled had been illegally diverted from the Republican River by Nebraska irrigators, many of whom were depleting streamflow through groundwater pumping. The Court recognized that groundwater was within the scope of the interstate compact between the litigating states to the extent its consumption impacted streamflow. The conflicts arising from these hydrological connections were a growing point of contention for irrigators.

As a result, Nebraska changed its statutory water law to avoid these conflicts, though it stopped short of providing a clear priority among surface water and groundwater users. Under Legislative Bill 962 (LB962), in the areas where surface water is fully or over appropriated, hydrologically connected groundwater is managed to bring the supply and demand for water into balance. Surface water appropriations are also managed to reduce demands when necessary. To accomplish this, significant changes were made to the institutional structures that, up until that time, had operated independently of one another.

Finally, although concern for water sustainability is found in state statutes, a major driving force of modern groundwater management in the state has been the protection of streamflow for purposes of ensuring compact compliance and meeting the obligations imposed by the Endangered Species Act. This federal authority requires state institutions to abide by limits tied to ecological indicators (e.g., species abundance) while continuing to account for social pressures (e.g., increasing demand for agricultural products), legal constraints (e.g., lawsuits), and meteorological markers (e.g., streamflow).

17.4 INTEGRATING NEBRASKA'S SURFACE WATER AND GROUNDWATER INSTITUTIONS

One of the main challenges of moving toward a more integrated polycentric approach to water management was bridging the gap between the vastly different sets of legal rights (surface water prior appropriation and the correlative rights of groundwater users). Groundwater users vastly outnumber surface water users. The management institutions are also markedly different. The NeDNR agency is tasked by the state to protect water supplies and administer related laws and programs, while the NRDs are governed by boards elected by local residents. The NeDNR is incentivized to engage in basin-wide conservation planning while individual NRDs may face pressure from constituent agricultural producers to develop groundwater resources (Aiken, 2005). To reduce the tensions between surface water protection and groundwater utilization, the NeDNR and NRDs were brought together in integrating management planning.

[4]Current requirements entail purchasing a permit corresponding to the rate of extraction. For <50 gallons per minute the registration fee is $70 USD, and $110 USD for >50 gallons per minute (State of Nebraska, 2012).

17.4.1 Integrated management plans and basin-wide planning: accounting for cross-border challenges

The 2004 passage of LB962 directed the NeDNR to declare portions of the state fully appropriated and over appropriated by January 1 of each year. The main driver of the designation is the (in)sufficiency of surface water supplies. The NeDNR evaluates surface water supply as insufficient if the most junior irrigation right holder in the last 20 years has not received 85% of the water needed for a corn crop from May 1 to September 30, which is the irrigation season, or has not received 65% of the water needed for the corn growing period July 1 to August 31 (regulation Title 457 Neb. Admin. Code Chapter 24 in State of Nebraska, 2021). This is called the '65/85' rule.

The Republican Basin and the Platte River Basin are affected by overconsumption (Bleed & Babbitt, 2015). When a basin is declared *over appropriated*, it means that 'existing uses exceed the supply and surface water flows can be expected to drop until either there is no water to use or the cost of using the water is too great to result in beneficial use' (Nebraska Department of Natural Resources, 2005). A *fully appropriated* basin has a cumulative demand for surface and groundwaters that matches available supplies. Basins in this category must be managed carefully in order to avoid entering over appropriation in the case that the uses in a basin overreach the long-term supply (Ibid).

The NeDNR evaluates basins for the presence of hydrologically connected groundwater and projects the impact of pumping on surface water supplies in order to determine whether supply meets usage. This involves an analysis of whether a certain number of years pumping a hydrologically connected well will deplete a river or base flow by a particular percentage. In the case of the Platte River Basin upstream of the Kearney Canal Diversion, the North Platte River Basin, and the South Platte River

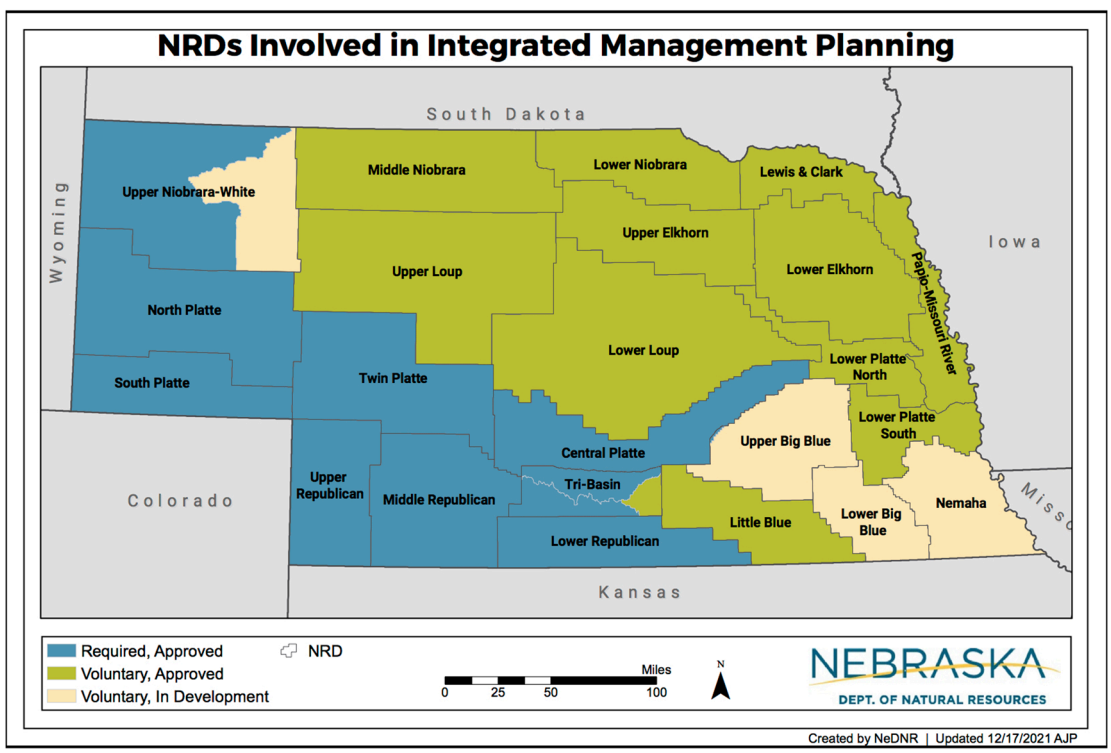

Figure 17.1 Natural Resources Districts with Integrated Management Plans as of December 17, 2021. Source: Nebraska Department of Natural Resources. Reprinted with permission.

Table 17.1 Examples of how NRDs have made institutional changes to allow for various control measures to sanction users and control groundwater over abstraction.*

Natural Resources District and Revision Order Document Name	Examples of Institutional Changes	Types of Sanctioning Allowable for Violations
Upper Republican NRD Order No. 34 Adopting Ground Water Controls (2018)[5]	Amended groundwater rules and regulations for the 2018–2022 period; spacing requirements for industrial and commercial livestock wells; changed criteria for the transfer of irrigated acres	The District can revoke or reduce irrigation allocation permits if compliance is breached. Violators are subject to further sanctioning under District rules and Neb. Rev. Statute.
Upper Big Blue NRD Groundwater Management Rules and Regulations (2020)[6]	New rules for Groundwater Management Area #1 and #2 to supersede previous GMA rules	The District can issue a cease-and-desist order to enforce withdrawal rules and regulations; violators can request an adjudication hearing. The District set new rules for groundwater transfers, and reserves the right to revoke authorization.
Lower Platte South NRD Groundwater Rules and Regulations, Revised (2020)[7]	Establishes a Groundwater Management Area that includes the entire District	Allows for mandatory education requirements to reduce groundwater depletion; authorizes District compliance officers to issue a cease-and-desist order for abstraction violation, followed by subcommittee consideration, and eventually a civil misdemeanor for non-compliance
North Platte NRD Rules & Regulations for Enforcement of the Nebraska Ground Water Management and Protection Act and the Nebraska Chemigation Act (2019)[8]	Establishes procedures for violation of the Nebraska Ground Water Management and Protection Act	The District can issue a cease-and-desist order when acts or activities violate state or District rules; a hearing may follow; penalties may be imposed as determined by the Board and/or future allocation amounts may be accordingly reduced; violations can result in civil penalties from $1000–$5000 per day of intentional violation (p. 54)

**For further information see individual Orders and Rules demarcated with footnotes. For an overview of current NRD use of rules and sanctions, see Nebraska Association of Resources Districts (2021), particularly page 8, for a mapped list of management actions and controls used in individual NRDs.*

Basin, the NeDNR issued a '28/40 line', referring to 40 years of pumping resulting in a 28% depletion (State of Nebraska DNR, 2004). This order was renegotiated to the 10%/50 year test – in other words, that 50 years of pumping a hydrologically connected well will deplete a river or base flow by 10% or more (Neb. Admin. Code title 457, ch. 24 in Aiken, 2005). Hydrologically connected areas are the main focus of integrated management since it is the pumping in these areas that impacts streamflow. This is an attempt by the NeDNR to address cross-border problems and link NRD actions together in a coherent way to address stressors in larger hydrologically connected areas. Furthermore, the NeDNR has pushed for repurposing surface water infrastructure to recharge groundwater and maximize the use of surface supplies in lieu of groundwater when the supply of surface water is high.[5678]

[5] For specific details see https://www.urnrd.org/sites/default/files/files/20/rulesregsfinal2018.compressed.pdf

[6] https://www.upperbigblue.org/sites/default/files/files/328/rule_5_as_adopted_august_20_2020mod.pdf

[7] Available online: https://www.lpsnrd.org/sites/default/files/files/89/ground_water_rrs_2020_final.pdf

[8] https://www.npnrd.org/assets/site/documents/rules-and-regulations/rules--regs-final-effective–9.11.19.pdf

17.4.2 Procedures for over-appropriated basins

Once a river basin or reach is designated fully or over appropriated, the state and NRDs must co-create Integrated Management Plans (IMPs) within 3–5 years. IMPs stipulate when further water development is no longer possible. IMPs are designed to reduce the strain that groundwater pumping can have on surface water flows, and vice versa, to protect surface water flows that are beneficial for groundwater recharge (Reed & Abdel-Monem, 2015). Figure 17.1 depicts the status of voluntary and required planning.

The IMP process requires setting clear goals and objectives to protect the balance between supply and demand. In drafting plans, each fully or over-appropriated NRD must include a map of the management area (which could be a portion or whole of the NRD extent) and set a minimum of one ground and surface water control and a plan for monitoring availability and use. Once adopted, NRDs and the NeDNR work toward achieving IMP goals by imposing controls. These include, for NRDs, the ability to set pumping volumes, prescribe cropping rotations, limit new irrigated acreage, and build augmentation projects. NeDNR has fewer tools to use, though it can limit new appropriations or prohibit diversions when necessary to achieve IMP goals (e.g., compact compliance and meeting Endangered Species Act obligations). The majority of the controls are set locally within the NRDs.

While the initial push for integrated management was somewhat difficult, today there is a high level of interest. Now, the NRDs routinely use their authority to actively manage groundwater. Those authorities include the ability to allocate the amount of groundwater that can be withdrawn, adopt a rotation system of groundwater use, set well spacing requirements, set flow meters or other measurement devices, reduce the number of existing irrigated acres, limit or prevent expansion of irrigation, and place moratoria on new wells or uses (Neb. Rev. Stat. § 46-73; Peck, 2007). Individual NRDs retain the option to use other rules or regulations in order to implement groundwater management objectives (Neb. Rev. Stat. §46-703 in Schutz, 2015). Table 17.1 below offers examples of how NRDs have used their individual authority to revise rules. The use and combination of these measures varies and NRDs do not all use these authorities in the same way. The differences are most evident in comparisons of sanctioning measures like allocation amount adjustments, flow meter requirements, well moratoria, or required water use reporting.

17.4.3 Implementing controls: North Platte Natural Resources District

As an example of the authority granted under the 2004 NeDNR Order[9], the North Platte NRD used its 2009 IMP to declare the North Platte River valley and Pumpkin Creek areas over appropriated and the remainder of the NRD fully appropriated. This followed years of special attention to the area, particularly after the *Spear T Ranch* legal conflict mentioned above (Aiken, 2005). The resulting allocation controls were set by the Board of Directors for the over-appropriated areas (specifically Pumpkin Creek). This decision was spurred by a multiyear drought. In November 2015, the Board of Directors voted unanimously to reduce the irrigation allocation limit to 70 acre-inches of groundwater per acre for five-year periods (North Platte Natural Resources District, 2021), with a yearly average of 14 acre-inches (North Platte Natural Resources District, 2016). As part of these rules, the 'severely overappropriated'[10] Pumpkin Creek sub-area has a separate limit of 60 acre-inches with a base allocation of 12 acre-inches per irrigated acre. The area, furthermore, is closed to new well permitting (with the exception of replacements for existing wells, or wells for humans and livestock animals), and all irrigation well owners must use flow-meters[11]. The North Platte NRD case illustrates an instance where allocations have been reduced to match declining water availability.

[9] https://dnr.nebraska.gov/sites/dnr.nebraska.gov/files/doc/water-planning/upper-platte/orders/OverappropriatedOrder9-15-04.pdf

[10] https://ngwa.confex.com/ngwa/gw19/webprogramarchives/Paper12669.html

[11] For current information on the Pumpkin Creek Basin Groundwater Management Sub-Area, see the information from the North Platte NRD's Water Management website: https://www.npnrd.org/water-management/pumpkin-creek-basin.html

In addition to reducing allocations, NRDs encourage stakeholder interaction around the topic of decreased water availability, and simulated decision-making. Individual initiatives related to unique challenges, such as drought, are becoming more common. Because of this, some NRDs have held interactive scenario exercises to plan for droughts. The North Platte NRD held a drought tournament in 2016, in which various scenarios were pitched to stakeholders, who had to make decisions about water allocation and resource sharing in order to mitigate potentially devastating impacts. After the tournament, the NRD created a Community Drought Plan, which outlines goals and actions related to education and preparedness for future water shortages[12]

Table 17.1 shows how institutional changes allow for new sanctioning mechanisms. NRD Boards can place moratoria on well withdrawal in stressed basins, but do not have to rely solely on this type of sanction. Not only are these allocations subject to statutory change, they are sometimes re-negotiated on a voluntary basis by a mixture of mechanisms including but not limited to buy downs, short-term leases, and supplementing one source for another – for example diversion of excess surface water into irrigation canals, pits, and reservoirs to make up for reduced groundwater availability.

17.4.4 Advantages of the NRD model

NRDs involve public and private stakeholders in place-based collaborative decision-making. This local involvement builds trust (Sixt *et al.*, 2019). Muñoz-Arriola *et al.* (2021) find that the IMP process has been accepted by local groundwater users because it reduces uncertainties. Collaborative leadership initiatives were built into the institutional design of NRDs. Initially, the head of the State Soil Conservation Service and a state Senator had the vision to obtain additional funding for conservation districts, with the aim of improving water management (Fairchild, 1994). Today, state water leadership networks continue as conduits for scientific, social, and political knowledge about water resources (Burbach *et al.*, 2020).

With their professional expertise, leaders in the NRD Boards reserve the right to decide whether groundwater pumping is allowed in a particular area; a key mechanism to do this is certifying 'irrigated acres'. The North Platte NRD does this by linking allocations to tracts of land and their associated wells, for example. When irrigated acres are separated or sold, they must be re-certified by the district (see North Platte Natural Resources District, 2016) and approved by the Boards.

Integrated management has been incentivized through funding opportunities at the state level; subsequently, all NRDs have developed IMPs (even those not fully or over appropriated). In fact, after the 2017 evaluation of water supply and use, all NRDs in the state either have a required or voluntary plan. In its 2021 evaluation, the state was exempt from carrying out a separate evaluation because all 23 basins are undergoing integrated management planning. The state's position was that there is no need to re-evaluate any of the basin assessments since the 2017 annual report (State of Nebraska, 2021).

17.4.5 Limitations of the NRD model

Though Nebraska's polycentric water governance model is ambitious in its scope to integrate groundwater and surface water management, it is not flawless. Generally, it may suffer from an observed weakness of polycentric systems: when environmental problems exceed the boundaries of a governance system, it is not clear exactly where to turn for the needed guidance or rule-making authority (Morrison *et al.*, 2019). Specifically, Muñoz-Arriola *et al.* (2021) find multiple concerns: that surface water provider participation is limited, the IMP process is not always equitable, irrigators have limited influence especially decisions about the extent of controls on ground water use that impact surface water supplies, and conflicts are not effectively managed. Water quality may be a more appropriate area for NRDs to address: for example, Sixt *et al.* (2019) find that the collaborative

[12] https://www.npnrd.org/drought/climate/weather/drought/drought-planning/

arrangement works well for governing groundwater nitrate levels but say little about its ability to govern water quantity.

Furthermore, there is limited quantitative research available synthesizing the impact of the IMP process on actual ground and surface-water levels. This is either because what is available is anonymized for confidentiality or the information is presented as non-scientific, unqualified demonstration of success. For example, a general trend of net minimal groundwater depletion (roughly 2 m) from 2002 onward in wells within three selected NRDs is presumed to result from a combination of streamflow withdrawal reductions, drought reductions, and also IMP governance resulting in recharge (Muñoz-Arriola *et al.*, 2021). Other sources make the vague claim that, as a whole, groundwater levels throughout the state have benefitted from NRD management, but only when compared to other states above the High Plains (Ogallala) Aquifer. The Nebraska Association of Resources Districts claimed a groundwater increase of more than 85 ft (25.9 m) in areas; meanwhile Texas has seen drops of 234 ft (71.32 m) (Nebraska Association of Resources Districts, 2019).

17.5 CONCLUSIONS

In Nebraska, groundwater and surface water are managed in a somewhat coordinated polycentric model, which offers needed flexibility given the growing demand for irrigation coupled with cyclical changes in water availability. The NRDs' IMPs are a key component for basins in crisis (over appropriation), and the Republican and the Platte River basins offer examples of how Nebraska's water governance model holds up in fully or over appropriated basins. The localized model, together with state and federal planning and legal mechanisms, is designed to mitigate the impacts of diminished supply. It has the advantage of involving public and private stakeholders across levels of governance.

However, there are also shortcomings and limitations. The model of groundwater allocation, in particular, requires a great deal of stakeholder participation and the active oversight of a Board of Directors. When participation and oversight are lacking, lawsuits related to breach of allocations have ensued, pushing the state to revise its statutes, particularly to address the challenge of managing hydrologically connected waters. Furthermore, the disparate legal philosophies and mechanisms used in over-appropriated areas can cause problems: when sanctions are used on groundwater access, irrigators can be subject to the fluctuating availability of surface water. Droughts and annual changes in water availability can create conflicts in hydrologically connected areas. Integrated management planning is now beginning to address these challenges. If NRDs exercise their full potential in designing and implementing these plans, with stakeholder involvement, conflicts may be reduced while increasing the sustainability of water supply in Nebraska.

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