In the Republican River Basin, all water comes from precipitation including stream flow and filling the aquifer. So the question is, "How do we best manage the water in a comprehensive way to maximize the benefits?"

It started with ditch irrigation and then dams were built to reduce flooding and to increase ditch irrigation. After that came groundwater irrigation using the aquifer as a reservoir.

A research paper "Damming the Prairie: Human alteration of the Great Plains River regimes", by Costigan & Daniels.


Fig. 1. Location of systems used for analysis, where gray circles indicate gage sites used for analysis. The boundary of the Great Plains USA is delineated in light gray.
The document shows that stream flow in the Republican River was reduced by 65% after dams were built. Small livestock ponds, terraces and residue management are also negatively affecting stream flow. Later changes in tillage practices further changed the local hydrology.

<table>
<thead>
<tr>
<th>River</th>
<th>State</th>
<th>Dam Name</th>
<th>Mean Annual Pre Dam Impact</th>
<th>Mean Annual after Dam Impact</th>
<th>% Change</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arkansas</td>
<td>CO</td>
<td>John Martin</td>
<td>8.27</td>
<td>3.4</td>
<td>-59</td>
</tr>
<tr>
<td>Canadian</td>
<td>NM</td>
<td>Ute</td>
<td>9.66</td>
<td>1.19</td>
<td>-88</td>
</tr>
<tr>
<td>Kansas</td>
<td>KS</td>
<td>Tuttle-Milford</td>
<td>104.87</td>
<td>147.42</td>
<td>41</td>
</tr>
<tr>
<td>Lower Missouri</td>
<td>NE</td>
<td>Gavin’s Point</td>
<td>727.18</td>
<td>735.11</td>
<td>1</td>
</tr>
<tr>
<td>Upper Missouri</td>
<td>MT</td>
<td>Garrison</td>
<td>624.1</td>
<td>624.39</td>
<td>0</td>
</tr>
<tr>
<td>Pecos</td>
<td>NM</td>
<td>Brantley</td>
<td>3.31</td>
<td>4.39</td>
<td>33</td>
</tr>
<tr>
<td>Red-North</td>
<td>ND</td>
<td>None</td>
<td>15.15</td>
<td>33.73</td>
<td>123</td>
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<tr>
<td>Red-South</td>
<td>TX</td>
<td>Dennison</td>
<td>137.25</td>
<td>138.13</td>
<td>1</td>
</tr>
<tr>
<td>Republican</td>
<td>NE</td>
<td>County</td>
<td>25.06</td>
<td>8.81</td>
<td>-65</td>
</tr>
<tr>
<td>Wakarusa</td>
<td>KS</td>
<td>Clinton Lake</td>
<td>5.32</td>
<td>7.62</td>
<td>44</td>
</tr>
</tbody>
</table>

These changes had a major impact on what the streams look like today. Unfortunately the riparian areas were taken over by undesirable vegetation such as fragmentizes. Russian olive, Salt Cedar and Red Cedar trees are adding to the problem.

That leads to the next question?

Since 2007 two weed districts have been working to remove the undesirable vegetation from the flood plain and to restore the stream back to health. In addition NRCS has developed: "The Stream Corridor Restoration" manual to help in this effort and covers the following:
I. Background
II. Developing a Restoration Plan
III. Applying Restoration Principals

The manual is available through NRCS or online vendors.

For every action there is a reaction and sometime there are unintended consequences. "The Stream Corridor Restoration" training should be required for those that serve on NRD and Irrigation District boards to better understand how streams function.

We have now laid the ground work for watershed management. Attached is an article by Frank Kwapnioski that explains how the water balance works in a watershed.
USGS has identified all watersheds in the US using Hydrologic Units that range in size from 1 through 12.
Example:
Missouri River is a HUC 10

The Republican River is a HUC 1025 and has identified 17 HUC watersheds.
A HUC 12 (102500060403) is south of Grant and happens to cover an enclosed watershed where no runoff comes in or out. It covers about a township in size.

Starting with a HUC 12 watershed the research can be quantified to show how much precipitation comes in and what happens to the water. Some of the uses occur as:

- Evaporation
- Aquifer recharge
- Livestock and human consumption
- Wildlife

  - Transpiration (from vegetation)
  - Municipal use
  - Aquatic life
  - Recreation

Since agriculture is among the biggest suppliers as well as consumers of water it is only logical that we concentrate on those uses.
Perkins County consumptive water use estimates for 2007

![Chart showing Perkins County consumptive water use estimates for 2007](image)

Examples:

- Average Rainfall: 35.48 Inches
- Growing Season Precipitation: 7,821,568 Inches
- Total Acres: 561,002
- Total Water Use: 7,821,568 Acre-Feet

<table>
<thead>
<tr>
<th>Crop Type</th>
<th>Acres</th>
<th>Inches</th>
<th>Depletion</th>
<th>Growing Season Precipitation</th>
</tr>
</thead>
<tbody>
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</tr>
</tbody>
</table>

- Perkins County, NE
- Adams Lumber Co.
- 12-Aug-17
Precipitation varies so much from one year to the next that makes comprehensive water management a challenge.

Satellite imagery can also help to identify consumption in real time and then use the data to help to better manage our resources to maximize the benefits.

Understanding and encouraging residue management as a tool to reduce evaporation and increase soil recharge is a win-win opportunity.

Changing cropping systems to reduce consumptive water use including shorter season corn may reduce usage.

**Summary**
If we are going to solve the challenges before us, steps need to be taken to balance the water availability with the demand. Today our demand exceeds what is available, so we have to find the most beneficial uses of our water without destroying our economic and environmental base.
Water Balance as a Watershed Management Tool

Just as the better you understand a subject, the better you are likely able to explain it, the better you understand a situation, the better you are likely able to manage it. Water balance is a tool that helps us better understand the water situation. It can help us understand, within a specific area such as a watershed, where all the water comes from and how much there is as well as where it all goes. This type of inventory is critical when it comes to deciding what we can and want to do with the water and where its best value may lie.

Water budget, as an engineering tool, has been taught for years as a specific set of steps to systematically assess a reservoir site or other water supply project and determine firm yield. The only difference, and the thing that is unusual with this approach from a conventional water budget application, is generally the balance application and the fact that water budget has seldom been used for this purpose.

Since the water supply is not uniform and static another important feature of a water budget, as a tool, is that it can be adapted to assess any scale and time frame appropriate to the management needs. Not only can it assess the full extent of the record but also the duration, magnitude and frequency of any recurring cycles which helps quantify the extent of risk and opportunity available in a given situation.

When this information is known it can help determine the need for and extent of storage possible and necessary to meet the expected demands. Only after you fully understand and quantify the water supply and expected and agreed to demand can you then start to identify where, how much and what type of storage is necessary and appropriate to address supply variability and meet the water needs and firm yield requirements.

Although we have already developed some surface water storage, because of various reasons it is not likely to be expanded much more. Therefore, identification and development of the best and most effective ground water utilization will be critical with ground water storage management the most possible and adequate in scale.

There really is no other tool that has systematically, on a watershed basis, address these expectations. Water balance is a tool, not a silver bullet, that when applied with appropriate knowledge and judgment can be extremely efficient at optimizing water management at scale. The opportunity for water budget application has recently been significantly improved with the availability of both remote and direct ET estimating and measurement.

In the past, without these resources and the ability for consistent implementation of this type of tool in a comprehensive manner, most water management amounted to simply attempting to react to what nature provided without systematic quantification. This understanding, essentially a “Tragedy of the Commons” outcome, can help explain why, after almost 150 years of water management effort, Nebraska still has periods of water supply excess, water demand shortage and water conflicts.
All systems operate within specific physical limits that are generally a given and must be observed. Other possible constraints to addressing water management issues are financial and social or political but with the abundance of necessary data and effective tools we now have available, financial concerns should not be a real constraint to watershed management.

The extent of water development can be financially constrained but the assessment itself should not be. With a water budget tool, we have all the resources necessary to manage water in Nebraska to the degree we need to be extremely effective. This generally leaves only political and possibly statutory conditions as limits and if these remain as obstacles, then the problem is self-imposed.
Stream Restoration Corridor Principles, Processes, and Practices

The manual is available at NRCs offices or it can be ordered online from a number of vendors.