Defining Ecological and Sociological Integrity for the South Platte River Basin

Proceedings of the 1992 South Platte Conference
October 27-28, 1992 – Fort Collins, Colorado

R. Craig Woodring, Editor

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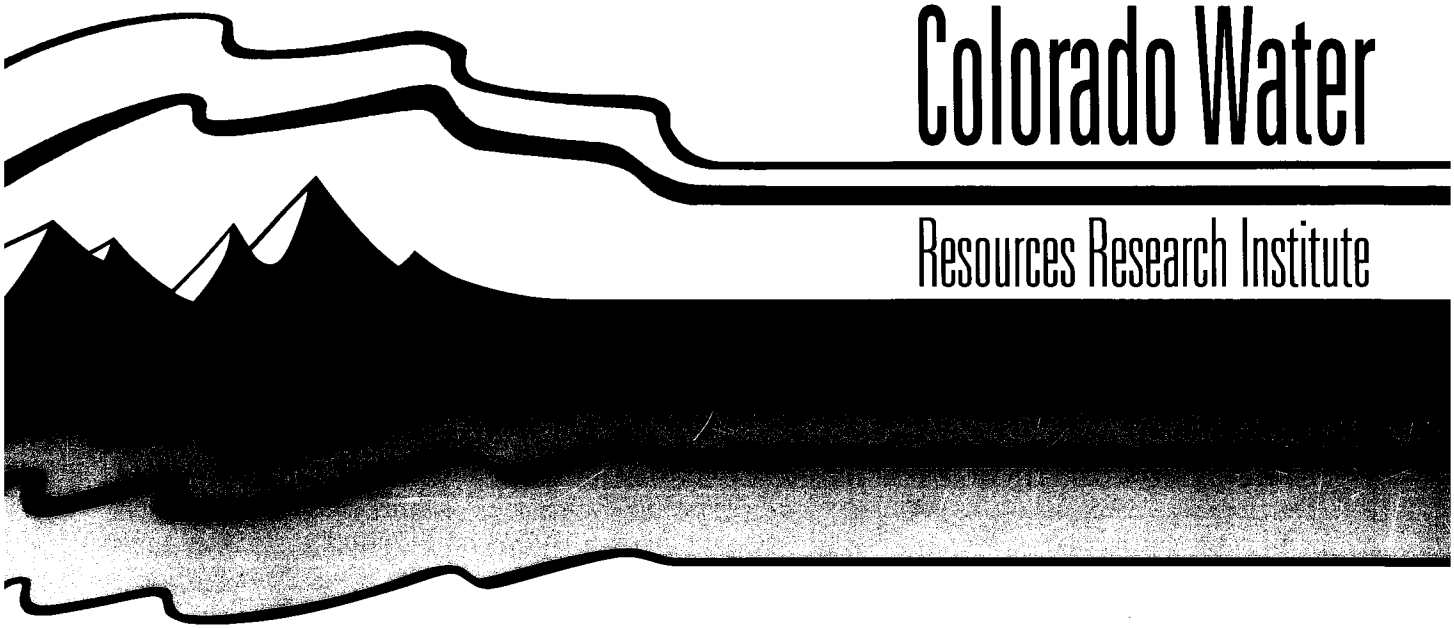

Colorado State University

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Sponsored by:
Colorado Division of Wildlife
Colorado Water Resources Research Institute
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Preface

The U.S. Congress' current direction on reauthorization of the Clean Water Act has brought a new term to water management - ecological integrity. What does this term mean? What will be its implications for water management in the Western United States? How will the South Platte Basin be changing under this new federal mandate? Must the ecology of the region return to what it was before European influence - high plains desert and mountain meadow? The Clean Water Act has been a forbearer of new innovative thinking in water quality management and the way we look at the entire environment. How will the latest version affect our lives? How can we as water managers and citizens of the Basin take direction for our way of life under these uncertain policies? How can we maintain sociological integrity of the basin while seeking ecological integrity?

In order to provide a forum for these important questions to be presented and discussed, the 1992 South Platte Research Conference was held October 27-28, 1992 at the University Park Holiday Inn, Fort Collins, Colorado. As the third annual conference, this meeting desired to follow the pattern of multi-disciplinary discussion and formulation of direction through better understanding of the South Platte River system. Cosponsors of the program were the Colorado Division of Wildlife, US Fish and Wildlife Service, Colorado Water Resources Research Institute, Denver Water Department, Environmental Protection Agency, U.S. Geological Survey, and Northern Colorado Water Conservancy District.

Target participants included water management organizations, citizen groups, agricultural interests, outdoor recreationists, resource consultants, local and regional government, university members, conservation organizaitons, and federal resource agency personnel. The format of the 1992 South Platte conference included six invited presentations that sought to define the past and present ecology of the South Platte Basin. Short presentations on specific aspects of the South Platte Basin were made as well as panel discussions and audio-visual presentations.

Whenever we talk about defining ecology and ecological integrity and looking at the interface to the concept of water management, invariably one gets into discussing the values, attitudes, and perceptions of ecology and water management. There is a role, if you will, for those in our society who try to communicate and relate values. Communicators need to capture the essence of what people are thinking with respect to the environment and then put that into a form that a lot of us can read and think about. These proceedings are compiled to reference the 1992 conference and the valuable insights it brought forward. For specific questions about the presentations, please contact the authors at the addresses given at the end of each papers transcript.

As editor and publisher of these proceedings, we hope they assist in developing a dialogue that will lead Colorado toward a means of defining the ecological integrity of the South Platte River System.

R. Craig Woodring, Editor
Robert C. Ward, Director, CWRRI

Keynote Speakers

The Great American Desert: Popular Myth and Water Development Along the South Platte

Brian Werner

Northern Colorado Water Conservancy District

I think we have come a long way since Pike and Long, who were some of the first Anglo-explorers out here in the West. They would not comprehend that there could actually be people inhabiting this area, let alone entire conferences devoted to water issues. All they knew in the early 1800's was that there wasn't a lot of water out here. As for this issue of ecological and sociological integrity, they would not have had any idea what we are going to talk about in this conference. Yet we are going to spend the next two days trying to deal with this subject. In order to do that I have been asked to come and talk about the historical perspective behind water development. How did we get to the point we're at?

We hear quite often in the water business -- "If we could just go back to the good old days before man ruined the rivers." What were the good old days - if that is what people classify them as - what were they really like? What was the South Platte River like 150 or 250 years ago, before modern western man got involved with it? What I want to do particularly is discuss popular myth, misconceptions and misinformation that all played a role in developing the American mind-set towards water development in the West.

Let us talk about the Great American Desert --that myth and perception by the American public-- and how that perception changed following the Gold Rush. From this we will look at what came about following the initiation of the agriculture industry in Colorado; how irrigation and water development fit into that whole plan; and then finally try to bring us somewhere back towards reality. The fact is that Colorado is a semi-arid region and it doesn't get enough water from Mother Nature to meet all the needs.

I am going to look at three basic mindsets towards water in the West. The first will be the mindset of the pessimists as I call them. These were the Great American Desert supporters who were the earliest anglo-explorers and travelers who viewed the area that we are living in today. The second category was that of the optimists. These people went 180 degrees the other way and perpetuated the Garden myth. They supported the notion that there was all the water that one needed out West. All you have to do is come out, dig up the ground, grow crops, and the rain would come. Finally, I will move us back towards reality, to the realists and visionaries as I like to classify them as. These people started focusing more on scientific data and hydrologic fact as opposed to the blatant boosterism of the people who came before them. This group saw the American West for what it was -- a semi-arid region. Irrigation was going to be a basic fact if people wanted to inhabit this part of the country.

At the same time I want to show you how thinking changed towards not only Colorado but the water supplies that were here in the West. I mentioned a couple times already that

I am going to focus on the Anglo-American experience in the West. I always like to emphasize that this doesn't mean there wasn't any water development prior to Pike and Long and the "white" invasion. In fact, the first irrigators in what is now Colorado date all the way back to Mesa-Verde and the Anazazi Indians in the 12th and 13th centuries. The Indians did irrigate crops at that time. However, I am going to concentrate on the Anglo experience where we have written diaries, records of expeditions, and the like.

Let me start with this desert image -- Great American Desert. We have probably all heard the term on more than one occasion. How did this myth become fixed in American minds, and primarily the eastern American mind because that is where everyone was living during the first half of the 19th century. I am going to do this with first-hand accounts of people who traveled in the American West and referred to this area over and over and over and perpetuated this Great American Desert myth.

It was first announced in 1810, with the publication of Pike's journal. He came out in 1806-1807 and in his journal one of his famous statements about the area where we now live is:

> "...these vast plains of the western hemisphere may become in time equally celebrated with the sandy deserts of Africa."

He compared it to a desert. Pike also saw a big advantage to having this desert in the American West because he saw it as a bar to westward settlement and that it would prevent this reckless extension of the country. This idea was to undergo considerable change 50 years later with the advent of Manifest Destiny.

Stephen Long is probably the most famous of the explorers who labeled the Great American Desert. He is the person who we can probably go back to and pin-point as the creator of the desert image in most peoples' minds. He came West in 1820 and said that:

> "...this was a barren region unfit for the habitation of civilized man."

But it was a botanist and geologist, also on the Long expedition, that had the most impact on Americans' minds. This gentleman, Edwin James, was the official chronicler of the expedition. He went back and drew up the very first widely-used map of the Western United States. On that map, from Texas all the way up to Canadian border, he wrote Great Desert across the middle of the country. This was published in 1832 and for the next 30 to 50 years everybody in the Eastern United States, particularly school children in learning geography, used the James map of the Western United States which had Great Desert right in the middle. It was also borrowed by magazines, and used by historians so that by the mid-1830's this Great American Desert notion was firmly planted in the American mind.

Then it picked up momentum. The desert notion was exaggerated at times and left an impression of the American West that it was simply unsuitable for people to move out here and live. It wasn't an impression that inspired people to move out West.

A few more examples of the Great American Desert idea will emphasize this point. Francis Parkman was one of the earliest visitors to Colorado and certainly one of the most literate. He traveled west in 1846 and published a book called <u>The Oregon Trail</u>. In a chapter

entitled *"The Lonely Journey"* he describes his travel across Colorado from Ft. Laramie to Pueblo, right through the area that we are sitting in today. Let me read one part he wrote:

> "On the fifth day...we saw, late in the afternoon, what we supposed to be a considerable stream, but on approaching it, we found to our mortification nothing but a dry bed of sand, into which the water had sunk and disappeared."

Many people read Francis Parkman, as he was the leading historian at that time. They read The Oregon Trail, and perpetuated this notion of a Great Desert in the West.

Daniel Webster was one of America's famous statesmen, and has one of my favorite statements about the American West. Writing in 1852 he said,

> "What do we want with this worthless area - this region of savages and wild beasts, of shifting sands and whirlwinds, of dust of cactus and prairie dogs? To what use could we ever hope to put these great deserts and these endless mountain ranges?"

Again, another reference to this area as a great desert. It is interesting that he couldn't see any use for the mountain ranges as well.

Most of us are familiar with Mark Twain. He came West in 1861 to strike it rich with his brother in the Nevada silver mines. On his way West he happened to stop overnight along the South Platte River near Julesburg. He speaks of this in his book Roughing It. He talks about the South Platte as such:

> "We came to the shallow, yellow, muddy South Platte, with its low banks and its scattering flat sandbars and pygmy islands - a melancholy stream straggling through the center of the enormous flat plain, and only saved from being impossible to find with the naked eye by its sentinel rank of scattering trees standing on either bank. The Platte was "up" they said - which made me wish I could see it when it was down, if it could look any sicker and sorrier."

Again, this is not the kind of description that is going to fire people to move out West. We have Daniel Webster, one of the leading statesmen in the United States, and we have Mark Twain who, was very well read, all helping to perpetuate the Great American Desert myth.

We also had people writing specifically about where people should or should not settle if they came out West. Lieutenant Governor Kay Warren was an explorer sent out West by the federal government in the late 1850's who wrote about the area west of Nebraska - where we live today. He wrote:

> "The people now on the extreme frontiers of Nebraska are near the western limit of the fertile portions of the prairie lands, and a desert space separates them from the fertile and desirable region in the western mountains. They are, as it were, upon the shore of a sea, up to which population and agriculture may advance, and no further."

This is interesting for what it implies about the South Platte River Valley here in Colorado. Warren is saying the U.S. is not going to be able to use that area of the West all the way up to the mountains.

Over and over, writers about the American West were saying the plains area was unusable, and they were figuring out ways to get through this desert area to the West coast. Elliott Coues edited Pike's journals, and in 1864 traveled the same route Pike did. He made an interesting statement about this journey and I think the statement could be said about the

South Platte River. He was writing about the variable nature of western streams which is emphasized time and again in diaries and journals. He writes:

> "Our route since leaving Larned has been mostly along the north bank of the Arkansas. Queer river that -- a great ditch chock full of grassy islets stretching through the treeless prairie like a spotted snake, some seasons so dry you cannot wet your foot in it for miles, and have to dig for a drink, sometimes a raging flood 200 yards wide."

Two references are important here. One is the treeless prairie -- time and again people equated the availability of water to whether or not there were trees. These people came from the Eastern United States where there was a lot of water and a lot of trees. They did not see trees out West and equated that with a definite lack of water. Second, he emphasized the ephemeral nature of the streams.

In sum we have writers, travelers, and explorers that all came West, wrote letters and stories about their travels all based on information gained from living in the generally the well watered regions east of the Mississippi River. The general impression was that this Great American Desert was no place for civilized Americans. It was treeless and it would be nearly impossible to raise crops. Even the beginnings of the trans-continental railroad fit into this desert myth. The U.S. viewed the railroad as connecting the Mississippi Valley with the West Coast through the imposing barriers of both desert and mountain ranges.

But, a funny thing happens when you look at the Great American Desert myth. Along came the 1859 Colorado Gold Rush and it wasn't too long after that the Great American Desert myth began to lose steam. It did so because people started coming west in greater numbers. There was a lot more pressure for expansion further west as settlements started moving up the Platte towards the Rocky Mountains. I mentioned Manifest Destiny before. This idea was that it was the United States' destiny to stretch from coast to coast and possibly even into Canada and Mexico. There were additional hydrologic facts that helped transform this Great American Desert myth into a Garden myth. This included the fact that 1860 and 1861 were very wet years in Colorado. The 1870's for the most part were a very wet decade and these helped fuel many false notions about water supplies in the West. There were many people who contributed to this transformation.

There were the boosters, the land promoters, the schemers, the romantic western novelists, and in many instances, the journalists who began coming out West in larger numbers to see what this region had to offer. I lump these people responsible for this transformation into a group called the optimists. These were people that said either there was indeed a way to lick the climate, or that climate would adapt itself to mans' needs as they moved west. These people also understood that water development was critical if they were to live here. They had to irrigate crops to be able to survive.

Within the optimists category are a number of groups. The first I refer to as observers. These were the people that first began questioning the Great American Desert notion. The idea of a great western prairie began to emerge in more and more writings. We see this transformation from the Great American Desert to the Great Western Prairie. Instead of the treeless plains it becomes the "Great" Plains.

The second category is the boosters. Many boosters had a reason for publicizing the territory, state, and some for personal gain. There were many who had almost a religious fervor in their promotion of Colorado and thus it would be impossible if people believed in the Great American Desert myth. These boosters had to find a new image and this is where the Garden myth really was developed.

Probably the biggest of the boosters was William Byers and his Rocky Mountain News. Byers was one of the most visible supporters of the creation of Jefferson Territory in the early 1860's. He published his propaganda in the Rocky Mountain News to show that there was more inducement to moving west than just the mines. He realized that agriculture was going to be a key ingredient in motivating more people to move here. Many times Rocky Mountain News articles were copied *verbatim* in the eastern press, who wanted news from the West. Byers was a man who championed agriculture and in September 1859, not too long after the first gold rush, he wrote an editorial called "*Resources of the Platte Valley.*" He wrote:

> "It has been frequently asserted by persons who have visited this part of the public domain that all that portion of Kansas lying west of the Blue River is a barren waste upon which nothing would grow; and this is, I am well aware, the opinion of most of the people of the eastern states. Erroneous as this position may be, certainly there are large tracks of land that are barren and which can never be reclaimed to add much to the agricultural resources of the country. These are known as deserts, without water, timber or other growing facility. Such lands are situated east of the valleys of the Rocky Mountain streams and do not occupy, to any extent, the proposed Territory of Jefferson. All lands that have advantages of irrigation are susceptible of cultivation, particularly those that lie near the numerous water courses."

While he doesn't eliminate the idea of a desert, he states there is certainly no desert in Colorado [the Territory of Jefferson] and he also emphasizes that irrigation is going to be a necessity.

Edward Bliss, who was Byer's editor at the Rocky Mountain News, was also a big supporter. He attacked the desert notion head on, on numerous occasions. Writing in 1861, Bliss writes of this area and the Great American Desert myth:

> "The eastern portions of Colorado embrace that mythical region laid down on all the old maps as 'the Great American Desert.' It is almost needless to add that the discovery and development of the mineral resources of the Rocky Mountain region has furnished the evidence of over one-hundred thousand witnesses against the existence of the 'Desert,' ..."

he adds:

> "Nature withholds her rains from the plains of Colorado and admonishes her people that they must strive to overcome the deficiency by artificial appliances."

Bliss is hammering at the Desert notion while also saying artificial appliances must be used to irrigate land if people are going to survive out here. He was a big booster of agriculture in Colorado as was the Rocky Mountain News.

Irrigation in Colorado expanded following the Gold Rush. Some of the busted miners decided not to travel all the way back East, and many of them settled along the South Platte

River Valley to try their hand at agriculture. Crude ditches, generally small and not very long, were built by a few farmers who banded together. Byers and the Rocky Mountain News began to link agricultural prosperity to Colorado's prosperity. They saw that mining couldn't do it alone. On numerous ocassions the Rocky Mountain News came out with editorials saying that agriculture was an absolute necessity.

William Gilpin was the first territorial governor and Manifest Destiny was probably his most passionate vision. Gilpin saw the former 'desert' area as the eventual home for millions of people and he went about trying to attract people to the West. On many occasions he said this region was no desert, not even a semi-desert. In fact, he explained (speaking of eastern Colorado),

> "...these plains are not deserts...but the exact opposite."

About this time a notion began to emerge that agriculture was almost effortless in the American West, the plains were amply irrigated by underground and artisan wells, and that if you moved out West, Mother Nature would provide the necessary water supplies.

There were many people who supported this notion -- speculators, schemers, and the misinformed, including Horace Greeley and the Union Colony. Horace Greeley was the editor of the New York Tribune, the most widely-read periodical of its day and very significant to the American mind-set. Horace Greeley came west in 1859 and later published an account of his travels called An Overland Journey. In this he publicized the positives of the West. Horace Greeley saw water development as absolutely critical. Writing an editorial in the New York Tribune in April 1870, Horace Greeley talked of the West and water development:

> "I am confidant there are points on the Carson, the Humboldt, the Weber, the South Platte and the Cache La Poudre and many less noted streams which thread the central plateau of our continent, where an expenditure of $10,000 to $50,000 may be judiciously made in a dam, locks and canal for the purposes of irrigation and milling combined, with a moral certainty of realizing fifty percent annually on the outlay."

He goes on:

> "Whosoever lives beyond the close of this century and shall than traverse our prairie states, will see them whitened at intervals by the broad sails of windmills erected over wells, whence every gale or breeze will be employed in pumping water into ponds or reservoirs, so located that water may be drawn there at will and diffused in gentle streamlets over the surrounding fields to invigorate and impel their growing crops. And when all has been done that this paper faintly foreshadows, our people will have barely indicated, not by any means exhausted, the beneficent possibilities of irrigation."

This is a fairly rosy picture of the American West. Again, the New York Tribune was widely read and these readers weren't being fed the Great American Desert image. They were told that out west were 'gentle streamlets' everywhere they turned.

Nathan Meeker reiterates his boss's thoughts as editor of the daughter paper, the Greeley Tribune. He has an interesting prediction for the future which shows this optimism for development in the West. As editor of the Greeley Tribune, Meeker wrote in 1875:

"...for the Greeley Tribune is certain to be read in the coming time, not so much on account of its news as of its ideas, and this is what we predict: In 50 years from today the forty and eighty acre farms over the river, and in many other places in Colorado as well, will show the highest cultivation; beautiful trees will adorn the scene, fruits of almost every kind will abound, noble mansions, the homes of happy farmers will extend for miles and land will bring from $500 to $1000 an acre."

Now this is the kind of picture that might entice somebody to move to the Western United States! People were reading this. While Meeker may have been a dreamer with his "happy homes extending for miles" I think this illustrates how the image of the American West had changed. As the national press began to pick up this Garden myth, the vision had become firmly implanted in the American mind.

The transformation was also partially due to what people wanted to believe once their friends and neighbors and families moved out west. They wanted to believe that it wasn't this desert that had been so prominent for 50 years or more. If you were a westerner, it was almost unpatriotic for you to say otherwise.

This mythical vision was partially due to hydrologic conditions. The United States Weather Bureau wasn't established until November 1871. Accurate climatic data was almost impossible to get prior to that time and it took another decade or two to build up enough of record to make the information worthwhile. This was an opportune time for people to generate inaccurate information. This happened with a gentlemen connected with the Hayden Survey of the American west, a professor by the name of Cyrus Thomas. Professor Thomas writing in the 1860s and 1870s did more than any individual to perpetuate the theory which came to be known as "Rain Follows the Plow." This is what he said in 1868, a quote he later came to regret:

"Since the territory [of Colorado] has begun to be settled, towns and cities built up, farms cultivated, mines opened, and roads made and traveled, there has been a gradual increase in moisture... I therefore give it as my firm conviction that this increase is of permanent nature, and not periodical, and that has commenced within eight years past, and that it is in some way connected to the settlement of the country, and that as population increases the moisture will increase."

This came to be known as the "Rain Follows the Plow" theory. The idea was that if you moved out west and cultivated the land, Mother Nature would drop water on you. This was, again, before there was accurate climatic data. There were many people who believed this.

Thomas, however, had an even more outrageous proposal. If we think we hear crazy schemes today in terms of water development listen to what Professor Thomas proposed in the 1876 Hayden report. His proposal was to join the Arkansas and the Platte with a 200-mile-long canal in eastern Colorado, back up the combined waters and create a series of lakes for irrigation, while at the same time modifying the climate and increasing rainfall. He felt that the more water storage reservoirs -- the more water would fall from the heavens. In the Hayden Report, Professor Thomas wrote:

"My plan is to throw up an embankment running north and south from the Arkansas to the North Platte, curving east and west so as to follow the contour. Then, by throwing dams across the streams, turn the water into this reservoir. An embankment or wall, averaging 30 to 40 feet in height, would, as the average slope here is about 6 feet per mile, form a lake six to eight miles wide and 200 miles long."

And we think we hear some crazy notions today! Most of eastern Colorado would be a lake according to this plan. Even Hayden had problems with this. When he looked at the scheme from an engineering standpoint he estimated that the reservoir would be about 2 feet deep and that through evaporation and irrigation diversions they would have a hard time keeping the bottom moist. This is yet another illustration of how far the desert description of 30 to 50 years earlier had changed.

The last category of optimists I want to mention were the promoters. These were the people who had a definite economic reason for bringing people out West. They certainly were not going to perpetuate a desert image of the west. In fact they took hold of this Garden image and ran with it. This category included the railroads, the land companies and investment groups. They capitalized on what had been written during the previous two decades.

Again, a generally wet 1880's helped. When the promoters brought people out west they could say there was a lot of water - "look it's raining today." The promoters attracted people with ads. The Union Pacific Railway advertised the Platte Valley as a:

> "... flowery meadow of great fertility."

The Chicago, Burlington and Quincy Railroad said that all you had to do was:

> "... follow the prairie dogs and you will find good land."

Private land companies picked up on Professor Thomas's "Rain Follows the Plow" theory and stated that the rain-belt was indeed moving further west. In fact, they stated that at times the prairies were too soggy even for grazing. There were many reasons brought forth for this increase of water in the west, all prior to the establishment of a good climatic scientific data base. These included: that electricity discharged by telegraph wires produced an increase in rain; that the concussion in the atmosphere caused by passing trains increased the rain; and, that there was an increase in groundwater and evaporation through irrigation and cultivation.

Let me sum up the Garden myth before I try to move us back towards reality. I am going to do so with a statement by Reuben Gold Thwaites who wrote A Brief History of the Rocky Mountain Exploration in 1904. He sums up well this Garden myth. He writes:

> "It took over half a century to destroy this myth of the Great American Desert, for which Pike was responsible [he lays all the blame at Pike's feet]. We hear now and then the cry of the alarmist; that the limit of settlement in the great West is clearly in sight; but there is still room for tens of millions of vigorous colonists in the upper valleys of the Missouri, the Platte, and the Arkansas, and the great plains stretching north and south between them."

And here is the key:

> "The Great American Desert of our childhood may yet become the garden of the land."

People kept perpetuating the Garden myth by attacking the Great American Desert myth head on.

Whatever the case, the fact was that people were moving to this region in greater numbers. From 1886-1889 there were numerous towns that sprouted up along the trans-continental

railroad route. There were eight new counties formed in eastern Colorado during this four year period. There were indeed more people living in Colorado.

Now I'd like to move us back towards the middle, towards reality if you will. I've shown how we evolved from the Great American Desert to the Garden myth. What happened next is that you had a number of people who moved out here who began experiencing the harsh realities of living in the West -- of farming, of pioneering, of traveling. Those harsh realities began to catch hold. People began focusing more on how indeed to settle the west, how to farm it, and, particularly, how to occupy a semi-arid region that doesn't always get the plentiful water supplies from Mother Nature that the newspaper ad or brochure from the railroad company promised. This movement back towards reality from the 1880s on is a much more scientific approach with less emotion than earlier periods. It is a more objective look at facts and it is also a time when irrigation becomes an absolute necessity for people living in the West in terms of water development. This realistic approach includes such gentlemen as John Wesley Powell and Elwood Mead. John Wesley Powell does not get the credit he deserves for bringing a realistic vision to the settlement of the American West.

This group based their views much more on hydrologic fact. They had witnessed the realities of people moving in during wet years and having to leave during the dry years. This is illustrated in a quote by a writer, H.H. Finnell, who describing the late 1880's said:

> "For half a century this margin zone has been the scene of repeated cycles of frontier crashing, bankruptcy and abandonment. Greenhorn settlers have pushed out into the arid plains beyond the established frontier zone. They have messed up the place, gone broke, and vacated it to lie idle again until a new crop of suckers is ripe."

He is saying that there were a lot of people that moved in following the Gold Rush, possibly spurred on by the Garden myth, who didn't know what they were doing or getting themselves into.

These were the people who assumed that wet years were normal years and the dry years were abnormal. Reality was that less than 20 inches of precipitation was the norm in the American West. Because of this, these realists realized that water must be stored in reservoirs if people were going to survive. In addition, the land had to be irrigated with that stored water.

Some of you may be familiar with the name Elwood Mead. He was on one of the first faculties at Colorado State University. He also became the Wyoming State Engineer and later the Commissioner of Bureau of Reclamation. Mead was one of the first who called for a scientific approach to studying water supplies in the west. He also saw a need to reform the methods of distributing that water. One of the earliest proponents of conservation he said:

> "it is the duty of the state to foster economical use and to restrict, and if possible prevent, everything which encourages wasteful and pernicious habits."

He also emphasized that careful collection of data was necessary. Writing in the very first bulletin, State Agricultural College Bulletin No. 1 in 1887, Elwood Mead states:

> "The rapidity of the development of our irrigation interests by a people ignorant of the practice is without a counterpart, and has opened up many problems whose solution is urgently required, but

which will require years of painstaking investigation. The question of a change in climate can only be answered by careful observations running through a series of years."

Hard data was needed, you couldn't rely on this Garden era vision, where promoters were encouraging people to move west and the "water will be there."

Mead was also a big proponent of building reservoir storage which takes off around the turn of the century. Mead did a lot to encourage this. He wrote in another bulletin:

> "If the early floods could be stored in the mountains there would be ample late water supply and every farmer would have the success of his crops assured."

Mead also suggested the appointment of a commission to look at irrigation and frame a water code for the state of Colorado. He had much to do with the establishment of what became the State Engineer's office in 1889.

Finally, I want to talk briefly about John Wesley Powell who probably does not receive his just due. Many people have viewed John Wesley Powell as just some guy who wrote an adventure story about his trip down the Colorado River, which is probably how most of you are familiar with him. He is the one-armed, former army captain, that made the first rafting trip down the Colorado River and through the Grand Canyon. While Powell never wrote or published much, in terms of being a visionary he is probably the leader in turn-of-century America. He was far ahead of his times in terms of his view of water development in the West. His central ideas were interesting. He pushed for scientific surveys of the West. He wanted a reform of public lands policy and he saw that something needed to be done in terms of water development. He said that no part of the country west of the 100th meridian could be redeemed for agriculture without irrigation. Irrigation was an absolute necessity to John Wesley Powell.

In his 1878 report, <u>On the Lands of the Arid Region</u>, he took issue with the Garden myth. He proposed a general plan for settlement of the west and he also championed federal involvement in procuring water supplies. He felt that it was the federal government's responsibility to provide water supplies for those who chose to settle in the West. He also had an interesting idea which most people paid little attention to at that time. He wanted to see the West organized politically by river valley or watershed. Those of us in this room today might be interested in that idea if it had come to fruition. We probably would have saved some of the litigation that we've spent so much time and effort on through the years. Powell understood how important water and irrigation were to the West. He said:

> "there is one fact which must control our conclusions in considering most of the lands of the Arid Region, namely: Any district of the country which we may be studying is liable for many seasons in a long series to be without rainfall, when the whole supply must be received from irrigation."

Powell kept stating over and over that irrigation must be provided. He also said that the federal government ought to help determine where people settle so they aren't all over the place and don't have water available to them.

Powell truly wanted to find a workable plan for settlement of the arid lands. He became the second director of the U.S. Geological Survey, serving from 1881-1894. During that period he was a big champion of reservoir storage as absolutely essential to the West. He

also saw potential conflict in the government's policies. In 1893 he addressed the International Irrigation Congress in Los Angeles. This group felt there were at least one billion acres that could still be reclaimed in the American West. Powell felt that reality was about 20% of that total. He told the Congress:

> "I tell you gentlemen...you are piling up a heritage of conflict and litigation over water rights for there is not sufficient water to supply the land."

This is where he can really be viewed as a visionary -- with all the time we spend on lawyers and legal cases today.

Let's sum up Powell quickly. He felt that water needed to be available through storage, through building of dams by the federal government, but at appropriate sites. These reservoirs would also provide protection from floods, would allow reclamation of arid lands, and the controlled flow would prevent the wasteful runoff of water. Unfortunately, as I mentioned previosly, there was much opposition to Powell. He demanded that the West submit to a rational and scientific revision of the Garden myth. He wanted planning by coherent river and drainage basins. Powell felt that the responsibility for long-range planning in water development lay with the federal government. Shortly before his death in 1902 the Reclamation Service was established under many of those same principles that Powell had first championed 20 years earlier.

In summary, the reality of water development in the American West lay somewhere between the Great American Desert myth and the Garden myth. Popular myth played a big role in shaping American's views of the West and the South Platte River Valley, which we are spending our time focused on today. It has taken at least one hundred years to evolve to the point we are now at in terms of water development. As we continue the next two days and talk about ecological and sociological integrity, let's give some thought to what this river was like 100 years ago -- raging one year, completely dry the next. Finally, as we talk about these issues and debate their merits I ask that we try to use an objectivity and balance many like the realists used -- like Mead and Powell did around the turn of the century.

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Achieving Ecological Integrity Through the Federal Clean Water Act

Max H. Dodson

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I appreciate the opportunity to speak with you today. Over the last few years, the EPA has stressed the importance of examining entire systems, such as the South Platte Basin. The emphasis is on a watershed approach, rather than by point sources. For that reason, I think this is an innovative and outstanding conference.

I was asked to discuss the relationship between ecological integrity and the Federal Clean Water Act, as it applies to the South Platte Basin. I have a managerial background, and dealing with such a technical topic is a little scary. It reminds me of a story about the veterinarian who was also a taxidermist. Anyway you looked at it, you would get your dog back. The point that I am trying to make is that while I might not be able to answer all of your questions, I will, nevertheless, give a presentation on ecological integrity.

I would have to admit, looking back on my 21 year career with EPA, that not too long ago if someone from EPA was asked to give a speech on ecology or biology as it relates to the Federal Clean Water Act, there might not have been many candidates. However, I think things are changing, and the agency is placing additional emphasis on biological and ecological integrity.

This change can be largely attributed to EPA's Science Advisory Board report. It was initiated by Lee Thomas, the administrator of EPA's Unfinished Business Report, who emphasized the need for EPA to make overall assessments of its position. EPA considered the environmental risks they presently addressed and determined others that should be addressed. It was determined that EPA had been preoccupied with managing resources and the environment in order to reduce cancer risks. The Science Advisory Board, convened by Bill Reilly, recommended that there needs to be a balance, within EPA, between their emphasis on human health and on ecological health.

In a sense, the Science Advisory Board and the Unfinished Business Report reiterated the basic goal of the Federal Clean Water Act, which is to maintain and restore the physical, biological and chemical integrity of the nation's waters.

Let me illustrate the relationship between the Science Advisory Board's definition of ecological integrity and the goals of the Federal Clean Water Act. From the EPA's perspective, ecological integrity is defined as consisting of chemical, physical and biological integrity. In the past, we have placed considerable emphasis on chemical integrity and monitoring of chemical parameters. I do not mean to suggest that the approach, taken by EPA and the states in the past, is the wrong way to go. In fact, the successes across the country, based solely on chemical integrity, are very profound. For example, Lake Erie or the Jordan River have seen measurable improvements in water quality as a result of permitting chemical discharges. In regards to the Clean Water Act, the EPA feels that

because it consists of chemical, physical and biological integrity, ecological integrity is being addressed. The idea is that by combining the three, hopefully ecological integrity can be attained.

The question then becomes how is ecological integrity achieved? Historically, our foundation, and our fundamental regulatory tool have been water quality standards. Water quality standards have many perspectives.

The first is designated uses. The criteria vary based on whether you are assessing a fishery, water supply, body-contact water body, or an agricultural water supply.

In many instances, people assume criteria to be entirely quantitative, e.g. dissolved oxygen, BOD, or suspended solids. However, let me explain the term 'narrative standard' in the context of toxic substances. The foundation for regulating toxics is found in the Federal Clean Water Act. It is stated 'thou shalt not discharge toxics in toxic amounts.' A program called Whole Effluent Toxicity was created to test and develop protocol using bioassay techniques to control discharge of toxics. In the state of Colorado, *Cerra daphnia* (Water Fleas) and Flathead Minnows are frequently used to determine the effluent's potential impact on the biota. This technique is an example of how to implement a narrative standard and is an extremely important tool in terms of addressing toxic discharge problems.

Secondly, Anti-Degradation policy must be addressed. The Anti-Degradation policy states that the existing usage creates a 'floor' for the water quality. This base level must be maintained except in cases where important social or economic development conflicts. In any case, any activity that lowers the water quality must not lower it below existing uses.

An additional area that EPA is beginning to embrace, as an agency, is the development of biological criteria. One of the primary issues, in terms of developing biological criteria, is the need for well-established protocols. While EPA has delegated states to implement the Federal Clean Water Act policy, it has an interest in maintaining national consistency. The formulation of an established protocol for developing biological criteria will hopefullly standardize the process between the states.

In order to develop biological criteria, identifying and conducting biosurveys at unimpaired reference sites is extremely important. The majority of our major water systems have been exposed to the human experience at some period in time. This makes the process of establishing reference sites for determining biological criteria more difficult. The goal is to compare unimpaired reference sites with an impaired site and determine whether or not there are significant deviations.

The most difficult aspect of establishing biocriteria is determining why an impaired site is impaired. If you cannot do the detective work of identifying why a particular condition exists than it is difficult to determine a remediation that will return the site to a condition similar to that of the reference site.

In developing these standard protocols, EPA has been working with the states to develop rapid bioassessment protocols. These protocols define the methods and process of data collection and analysis. It is a necessary tool for assessing biological integrity. It has been developed for streams and small rivers. However, it has not been developed for lakes. It involves five levels of investigation, from sampling fish, which comprises three levels, to macroinvertebrates, which comprise the remaining two levels. When using this particular technique, the biology of the system is studied and the appropriate protocol must be determined. This rapid bioassessment protocol is used to qualitatively and quantitatively describe the site and create a basis for comparison against impacted systems.

This particular process is the subject of an upcoming workshop conducted by EPA Region VIII and EPA Region VII. The focus will be on the region's common water body, the Platte River System. The workshop will center on developing consistent biocriteria between the two regions. The goal is to use the Platte as a demonstration system for developing protocol. Protocol development does not sound as though it is an important process, but in terms of the levels of investigation you hope to conduct, and the standard methods you are going to use, the process of developing protocol becomes extremely important.

I have given youa sense of how the EPA defines ecological integrity in the context of the Federal Clean Water Act. However, there are a plethora of different perspectives, different organizations, and different goals that can be attached to a particular system. Therefore, there are questions that need to be confronted:

- Is what does ecological integrity mean to a system -- in this case to the South Platte? The examples of physical, chemical and biological integrity have been considered. Are there additional considerations?

- What are the overall implications of ecological integrity, not only for the Platte River, but for the West?

- How will the basic management activities need to be changed in order to emphasize the importance of ecological integrity?

- Is the goal a return to pre-European ecology? There is a realization in the lower Platte system that we are unable to return to a pre-European system.

- How do we define a direction for changes in our way of life under the policy of ecological integrity? Will there need to be specific changes in our lifestyles? Changes could very well be anticipated if we are to reach our biological goals.

- How do we maintain social integrity while seeking ecological integrity? The development of the Platte River system has continued over an entire century. Therefore, in terms of the social fabric of the local population, there very well may be conflicts between maintaining ecological integrity and maintaining sociological integrity.

These are some basic questions that lie beyond developing the protocol.

The EPA has been involved in funding a study of the South Platte and its tributaries. The study aims to find suitable reference sites. Our contractors, Science Applications International Corp. (SAIC) divided the Platte Basin into eight ecologically similar subregions, examined data, predominantly fish data, and ranked the potential sites. They ultimately determined eight that would be good reference sites.

I am going to walk you, using slides [not available for this publication. -- Editor], through the Upper South Platte system. One objective is to give you some sense of the diversity within just a small part of the entire Platte Basin. As you look at that system, ask yourself questions concerning not only the ecological integrity, but questions concerning the lifestyles, and practices requiring modification in order to protect the ecological integrity.

This is the southern portion of the basin, which some people refer to as a world-class fishery. As we proceed to an area above Cheesman, which I believe is Wild Cat Canyon, we are entering a much different environment. It has a relatively undisturbed riparian habitat. Moving into an area near Deckers, below Cheesman, the surroundings are again much different. This area is also described as a world-class fishery. Nearing Fairplay, there are some fairly profound human disturbances. In regard to the ecological integrity of this system, the condition of the riparian system needs to be addressed. In the system above Kassler there are drop structures that have a tendency to create problems for fish migration, as well as some basic chemical problems. Proceeding towards the Denver metro area there are again some profound changes occurring within the system. This is an area above Littleton-Englewood. Looking at a single shovel-full of the deposits found on the bottom of this system, the question arises, 'how will we ever be able to establish ecological integrity in this portion of the system?' Despite the appearances, this is a desirable niche for salmonids. In this area below Chatfield all the way to the Littleton-Englewood area, one might come to the conclusion that it is not a particularly viable fishery. However, it is quite viable. In fact, there are reports of large trout, up to 10 lbs. being caught. It is also reported that there are between 30-34 different species in that particular segment. This area of the South Platte is very diverse and healthy with regards to biological resources. Further down we come to the Metro discharge. During some parts of the year, the effluent comprises nearly 90% of the flow. After examining the biological integrity upstream of Littleton-Englewood, the question arises can the same conditions exist in this particular segment? There are dissolved oxygen problems associated with the drop structures. This is an interesting picture. From the standpoint of appearance, it looks healthy. However, a problem exists with the sediment's influence on the dissolved oxygen concentration. Preliminary studies suggest that approximately 50% of the dissolved oxygen problem can be attributed to uptake by sediment.

Recently, EPA sponsored a workshop in Fargo, North Dakota, focusing on biocriteria, bioassessment technology, and developing rapid bioassessment protocol. When establishing reference streams an eco-region approach is important. The concept of the eco-region approach is that when developing reference sites it is important to remain within a similar eco-system as that of the impaired site. For example, comparing a stream in Maine with

a stream in Washington may be very difficult as their climate, geology, land-use, soils, and other factors may vary greatly. Therefore, a comparison cannot be made.

Wetlands are an important area in terms of referencing biological criteria. As an example, consider the wetland resources of Lake Winnipeg, it is the only place where the Walleye reproduces effectively. Without those wetland resources we are without a fishery in Lake Winnipeg. Wetlands often provide a very important biological function. This is the Elm River in North Dakota. It appears to meet the criteria of a relatively undisturbed system that can be used for reference purposes. A biological investigation was conducted, and many benthic organisms were identified.

Many of the tributaries to the Red River are relatively undisturbed, and it is quite easy to develop a reference site. Therefore, a biological resource "score" for the reference site can be determined and used for comparison on impacted areas. The main stem of the Red River has been greatly disturbed for the last one hundred years. With the tributary established as the reference site, can you be assured that it has the same characteristics; flow, chemistry, land-use, soils, geology, climate, etc., as the impacted site? That is a real dilemma.

I have given a cursory view of how EPA defines and deals with ecological integrity. On a national level, we are determining how ecological integrity fits into the mission of EPA and the states. Change is occurring, as we are in the midst of an election, and the Federal Clean Water Act is up for re-authorization. Hopefully, the re-authorization will stress the ecological integrity aspects of the Act. Perhaps the goals will be articulated in greater detail and the importance of viewing the Act in the context of watersheds will be addressed. Most of the states are currently emphasizing the importance of targeting resources and watersheds. The EPA, in the past, has had a tendency to stress the importance of the point source program and routinely writing and enforcing permits. While there are successes within that approach, we are broadening our mission to target entire watersheds from the standpoint of chemical, biological, physical and ecological integrity.

In closing, I would like to leave you with a Platte River success story. As you all know, the Metro Reclamation Facility, previously called the Denver Metro Sewage Disposal District No. 1, was not particularly effective in protecting the South Platte River. In the late 1970's and early 1980's the river below Denver was nearing the conditions of a biological desert, as a result of the discharges from Metro. Over the last four years, Metro has increased their treatment, and solved their chlorination problems. In October of 1985, the percent mortality of *Cerra Daphnia* was approximately 50%. As a result of improved treatment, equipment changes and improved operations, this mortality rate was near zero in October of 1990. The biologists are seeing much more biodiversity, and biomass than in the past. I think this improvement has genuinely excited the Metro staff to the extent that they are actively working with the State of Colorado and the EPA on a very innovative project. I indicated earlier that the drop structures and the quiescence creates dissolved oxygen concentrations that are not able to meet the standards. The dissolved oxygen (DO) concentration has been measured at 2 ppm, which is below the standard of 4 ppm. That sends a strong biological message. The old agencies, the old EPA and the old state of

Colorado, might of told Metro staff that some nitrification and denitrification practices, on both sides of the plant, would be necessary to meet the DO standard. However, with regards to achieving the goals of biological integrity and ecological integrity, it has been mutually agreed that it makes sense to examine what options exist in altering the fluvial geomorphology, the hydrology, the riparian system, and the drop structures to solve the DO problem hopefully saving millions of dollars. There are still many options to investigate and everyone agrees that this area has a high potential for returning as a viable fishery as well as one that can achieve biological integrity.

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The Political Sociology of Defining Ecological Integrity: Why We Never End Up Where We Intend

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In a very real sense, we know well what ecological integrity means, and we know that we are tethered very tightly to the ecosystem. If we abuse that ecosystem, human-choice opportunities are quickly destroyed.

There is another sense however, in which we don't know what ecological integrity means. It is the same sense in which we are not really sure what living in the middle means. On one hand -- to use the metaphor of an automobile, a filling station and a gas tank -- if we insist that our gas tank remain absolutely full at all times, we will never run out of gas. We will be playing it very safely, but we will never get any potential out of that automobile; we will never go anywhere and we'll never do any work with it. On the other hand, if we're careless about measuring the gas in the tank, we can easily put ourselves in positions where we are not going to make it back to the station before the machine stops functioning. We don't want to move beyond those thresholds. Obviously, anybody with an automobile, a gas tank, and access to a filling station wants to live in the middle somewhere. We don't want to live with just full tanks all the time, and we certainly don't want to experience the collapse in performance that comes with empty tanks.

The question is, "How do we live in the middle with tanks that are partially full and partially empty?" That is always the question, and that's the part of ecological integrity that is hard to define. Everyone says define ecological integrity in the middle somewhere -- not pre-European impact and not pristine -- but always include me in the middle with the least cost of making any change. Since everyone wants to live in the middle and they want the middle to be defined in a way that will include them at the least possible cost, they always want others to bear the costs of maintaining and sustaining ecological integrity. I stand here with absolute confidence and say that whatever ecological integrity means, it will always be a social and political concept. It will never be defined to anyone's satisfaction in a narrow, technical way.

I want to explore with you some implications of living in the middle. The first problem is that we all want to be rational. The problem, of course, is that rationality is not a single thing.

Rationality has multiple definitions, and the different meanings of rationality are in conflict with each other. Everyone who comes to the table says, "But I am being reasonable and I am being rational; now will you please do the same?" Of course, what we really mean is: "Won't you be rational my way?"

Technical rationality is always the rationality of seeking one objective. We pick out an indicator species (or a keystone species) and our technical rationality focuses on how to create the habitat to make sure that the species doesn't go under in some period of time.

Another technical rationality has the objective of how do we accomplish one goal at this particular place. Of course, what is good for a given indicator species in the short run is not necessarily what is best for its surrounding ecological community in the long run.

Economic rationality is very different. Economic rationality has to do with how economists tell us to make trade-offs among goals using market prices. If you want to have more butter, you're going to have to give up some guns. Eonomists are constantly going to the blackboard and drawing a variety of production functions and indifference curves and telling us to move toward Pareto optimality.

Political rationality is again a different thing. It has to do with how we build and sustain a winning coalition. How can we get something done that doesn't come apart on us as we start moving through our projects and programs.

And then there is legal rationality. If you get a group of lawyers in the room, they talk about reasoning from precedent. How did the courts rule over a period of years? What have been the recent interpretations?

Ecological rationality has no substance other than some mix of these other varieties. When we talk about ecological rationality, we may be talking about it in a technical sense, an economic, a legal, or a political sense. And almost always we're talking about some unholy witch's brew of all of these. Everyone wants to make sure that the middle is defined to include them in ways that minimizes their personal costs and imposes burdens on others downstream or downwind.

The social and ecological environment within which we work, plan, gather and assess our data, and pull together our programs and projects, has some very significant and profound social and political attributes about it. I want to point out a few.

There are no socially neutral users of information out there in that social and political environment within which we do our studies and within which we build our programs and projects. Let's look at this for just a moment. What do I mean? Can't we be neutral and objective, can't we know something about ecological integrity? By virtue of the fact that we are rational decision makers, that we do seek to get the most possible gain for the least possible cost, we are up against the logic of externality.

As an explanation of this, if decision makers in the middle starts moving towards objectives, whether those of a federal agency, a state agency, a private corporation, or a university research team, they can easily create spillover effects -- if you will, externalities. These are the repercussions that fall external to the decision makers objectives. If we have negative externalities, these are the things that get in the way of other decision makers- other firms, other companies, other agencies, or other farmers downstream. Negative externalities are not liked. We do not want to highlight the negative externalities of our actions because they cost us allies; or to be more blunt about it, negative externalities create enemies. As I move towards my objectives and in the process create spillover affects that get in your way, I'm not making you my friend.

On the other hand, my actions can also create positive externalities. These are the nice things that happen as a consequence of my moving around in the environment and the ecosystem.

No one is a socially neutral user of information. There are no socially neutral decision makers out there. What we have is a variety of decision makers that each highlight positive externalities, lowlight the negative ones, and push to get into the middle. In the middle, they'll be included and hold onto the least cost option for themselves. That means they impose the costs on others. We do not do this because we are irrational; we are doing it because we are quite rational and because it makes sense for us individually. It may not always make sense for the collectivity.

Second, we cannot predict through long chains of probabilistic events. When you and I do our studies we are trying to find a few strategic things we can focus on. But the fact is we must hold aside all the confounding things that can intervene. And so we in the university teach a whole variety of research strategies about how to look at the key variables, x and y, while everything else is controlled. What that means is, if I go into my little niche and learn a great deal, I learn a great deal indeed. But now I must bring my little niche into connection with all of your little niches. You've been studying another slice of reality and somebody else still another. But as soon as we start combining what I know with what you know, we increase uncertainty (.8)(.8)(8)(.8)=.41, we are down to less than 50% in knowing what the outcome will be in the real world. In other words, as we combine our knowledge, and put it together with others, we lose knowledge. That's a fundamental reality of science.

We try to do systems analysis, but we are constantly coming up against the fact we do probabilistic science. When we combine our probabilities we multiply them, and when we multiply those probabilities we lose insight quickly. Here is a key point. Science gains knowledge by abstracting strategic slices from a complex whole and by studying these slices under conditions where confounding factors have been removed. But, there are great difficulties that we must confront when we start reassembling our fragments into useful, accurate, comprehensive pictures of the dynamic ecosystems. We do not do this well because there are fundamental limits on how we can predict through long, probabilistic chains. And so we are going to have to be modest in our aspirations.

It turns out then, that as we function in this environment where there are multiple and conflicting rationalities, we recognize that we're all trying to center ourselves in the middle to get the other folks to bear the burden. To this add the more we know, the more ignorant of some things we become. Then we come to the fundamental reality that in the social and political environment of the planner, we each have our constituencies with whom we want to relate, and they have decreasing access to the reality of the whole.

At this same time that we have constituencies who are specialized in their particular area, and therefore, have less and less access to the reality of the whole, we have more and more issues flowing into the public sector for resolution than ever before. We keep coming up with new technologies that generate more and more externalities both positive and negative. Just when we have less and less access to the reality of the whole, just when there

are no socially-neutral users, just when we can't predict through probabilistic chains, just at that time -- we have more and more things on our desk to look at.

And finally, small groups of people representing the tiniest factions can exercise veto power on the whole of the system. As an example, we see that when it comes to acts of terror; it doesn't take a big constituency to do that. A small number of people can exert veto power on the whole even though they have access to a very small fragment of that whole.

How do we respond? I can't give you any easy recipe; there is no magic formula. Ecological integrity will always be highly social and highly political, there is no getting around that. I think I can say two things in passing that we must not do on a negative side, and two that we must do on a positive side.

After twenty-five years of working in this area, in our culture and some others, and getting into some pretty tight scrapes having to do with natural resource utilization, I do know that we all need to overcome two kinds of arrogance.

The first kind of arrogance has it that 'my discipline is better than your discipline.' Simply, if you let a sociologist loose to define the problem and come up with a solution without staying very close to what the engineers, agronomists, economists, and biologists are saying, you can get yourself into a great deal of trouble. But it is equally true that if you are an engineer and define the problems of ecological integrity and start designing solutions without the other disciplines, you will botch it up just as badly as any sociologist ever would.

The second kind of arrogance that we must overcome is the thought that we, who are codifiers of scientific knowledge and abstract principles and who take pride in our respective disciplines, somehow have a superior form of knowledge. Those who work, possibly without college degrees, but close to the land and the water, have a different kind of knowledge.

I am very proud of the things that I have been able to abstract out of a rich world and been able to publish, but although I know something different than farmers know, than herders know, or local people know, my knowledge is not inherently superior to their knowledge. Theres is a different kind of knowledge. We have to overcome the kind of arrogance that says we who have our Ph.D's inherently have knowledge than they have and that they are to be manipulated according to our formulations. That does not work in this world, in our country or any other country.

What we have to do to overcome that kind of arrogance is to establish long term collegial relationships with those who are managing, working, and serving in a whole variety of organizations that are typically off the map for those in the state and federal government and universities.

When looking at ecological integrity or anything else, someone usually comes up with a policy. Policies have to be enacted into law sooner or later. Lawyers will codify that policy, but law is nothing more than ink in a book. It doesn't get anything done. Societies have been passing wonderful laws about wonderful things for a long time, but things begin

happening only when you start getting human beings organized. I refer here to main system organization -- the central bureaucracy. It could be the appropriate ministry in the capital city or in our cabinet departments in Washington D.C., or it could be the State Engineer's Office right here in Colorado. That would be main system. But main systems cannot manage any ecological piece of land and water from afar, from Washington D.C., or from Denver.

If we are to have effective management and do something sustainable to protect whatever ecological integrity turns out to be at a given point in history and in a given ecological patch, we always have to turn that over to a local organization. In this case, since I do a lot of irrigation work, I will use as an example local irrigation organizations. What do I mean by local? It could be a conservancy district, but almost always conservancy districts are too big to manage the water down to the farmers' fields. So, you are going to turn it over to a second or possibly third tier below a conservancy district--you are going to move into the realm of what we, in Colorado, call mutual companies.

And again and again and again, when I go to the federal government, to EPA, to US AID, or to other agencies, they have a vague sense that there is an organizational complex out there running land and water operations. They barely may be aware that there are things called conservancy districts, but I have yet to find people at that level who even know what a mutual company is, what they do, and how they pick up water and how they deliver it. Of course, how they manage water, how they move it from reservoir to reservoir, how they pick it up and put it down again has everything to do with whether you are going to have any fish or not and whether the birds are going to have any habitat or not.

What I am saying here is this: not only must we overcome the arrogance that my discipline is inherently superior to yours, but we must overcome the arrogance that we who have PhDs and Master degrees, we who have processed knowledge out of the textbook, somehow know what these local level people know. We simply do not know the kind of local, site-specific knowledge available to these local organizations. There is only one way we are going to find out, and that is to enter the local organizational realm as colleagues. We have to enter that realm as colleagues for the long term -- not for a week and not for a month -- we are going to have to make commitments for many years to work in this realm. Then we can adjust our generalized principles down to a particular patch or a niche. Local knowledge must come up and meet our generalized knowledge.

If we don't know that there are people already there on the water and land base who are managing it, and if we try to come in with our generalized averages and our central tendencies and say manage on the basis of them, we'll always miss important realities. Remember, statisticians always drown in lakes that average two feet deep. We tend to convert area generalized knowledge into central tendencies. We can quote an average flow of the Poudre River, but the Poudre River is never at the average; it is virtually always above it or below it. If you manage the river based on average you will always be missing the reality of the river. That's what our science gives us--the knowledge of central tendencies. Central tendencies don't work when you are in a particular patch.

Ecological integrity is always going to happen patch by patch, and that means let us overcome our arrogance that we who are in civil service systems and university systems

somehow know better. People in local organizations may need to know what we know. Yes, they may, and I don't denigrate area-processed disciplinary knowledge. But we need to know what they know about site-specific local conditions. That means entering into long-term, collegial relationships with these local organizations.

By way of conclusion, if we have any hope of moving toward increased ecological integrity, it is because we will have overcome these two kinds of arrogance and found ways to work together across disciplines and across the boundaries which separate the processed, generalized knowledge of the several sciences from the site-specific particulars of local people who manage the land and water.

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Ecological Integrity and its Effect on Managing Water Quantity and Water Quality

Alan Berryman

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I really appreciate the opportunity to be here this morning. I am glad to hear some of the comments, as I have wrestled with the term "ecological integrity" after finding out that I needed to substitute for Hal Simpson in this speech. Hal sends his regrets that he could not be here to speak to you this morning as he is in California, involved in a lawsuit between Colorado and Kansas on the Arkansas River. Hal called me Monday night and said, "I really do not think I am going to be able to make it back and I need you to give a talk on Wednesday up at Fort Collins. I need somebody to pinch hit for me." I said "Sure boss, I can do that. What is the talk on?" He said, "Ecological integrity and its effect on managing water quality and quantity." There was a long period of silence that followed. I did not know exactly what he was talking about. It took awhile for me to deal with the term ecological integrity because it is one that we, as water administrators or water managers, really have not dealt with in the past.

I will touch on a couple of areas. The first is a review of the development of the Front Range and water resources in the South Platte Basin that produces our current environment. Water development defines our system and has since the beginning of Colorado's settlement. The State Engineer was around even before we were a State. The office has been involved in water development and with water users for over a century. Secondly, I will touch on some of the institutional practices that we are involved with as water managers that you need to be aware of that could be used to enhance ecological integrity.

I will begin by addressing ecological integrity. I started from ground zero and went to the dictionary. Finally, I decided that, in a general sense, ecological integrity could be defined as a condition of unimpaired relationships between an organism and its environment. That definition expands very quickly, as an organism can be a plant or an animal and there are all types of environments along the Front Range and the South Platte Basin. As I struggled some more with that, I realized that we are trying to define ecological integrity and become more aware of the different aspects of it in this conference. I think each person, depending on their background and where they come from, has a slightly different idea of what ecological integrity means. I am going to consider ecological integrity in a general sense and focus on our basin's water and distribution system, and look at what Robert Ward referred to as the overall environment that we have developed over time.

Let us now go back in history to examine where we are at and how we reached this point. The major influence on our South Platte River system including tributaries has been water development and water use, which has been guided by the Colorado system of water rights. The water rights system has become very complex, especially in application of water. I think a look at this development might be useful for today's discussion.

The Great American Desert -- that is what we were looking at in the early 1800's before people really started to come out here. Some of the first western explorers, Stephen Long and Zebulin Pike, instigated this idea of a Great American Desert in the public's mind. Stephen Long came here in the 1820's and did not find anything that he was very enthusiastic about. One of the maps, drawn by him, of the Great American Desert, became fairly popular throughout the eastern United States. It was shown in schools, and in the general public's mind it became the image of what was in the west. Zebulin Pike came out west in the early 1800's. He said that:

> "the vast plains may become in time equally celebrated as the sandy deserts of Africa for I saw on my route in various places, tracts of many leagues where the wind had thrown sand in all fanciful forms of the ocean's rolling wave and on which not a speck of vegetable matter existed."

Reports like this that came from the early explorers delayed people settling the area. People did not think there was much out here. Those are the early beginnings.

People started coming out in the 1850's and 1860's because of mining activities. Let's look at the area 1850's, 1860's and 1870's, when people first settled the area. [Slides not available -- Editor] This is a picture of Greeley from 1870 or 1871. There are no 7-11's or anything of that nature. It is a bleak, barren area; vastly different than what we see today. This picture shows Greeley with water service. In about 1871, they put in a ditch. That is the Greeley No. 3 ditch in this picture. The ditches were used to irrigate small plots of land, and provide water to some of their animals. Nonetheless, it was undeveloped and a barren land.

This picture is of early Denver. Again, not much is there and it looks very different than the parks and turf grasses that we can see today.

As for Fort Collins, I have a quote from one of the early trustees of Colorado A&M, which is now CSU, discussing the land on which the school was going to be built. He states:

> "It is located in the Great American Desert with nothing in sight more than a dry prairie dotted with cactus patches, bestrewn with bleached bones of departed buffalo and inhabited with prairie dogs, coyotes and buzzards with only here and there a little oasis along the creek bottoms."

That gives you a good idea of what people saw when they first came out here. We have changed drastically since then.

What happened after that point in time? The people who settled the area were very industrious. They started irrigation projects. Guys like the fellow in this picture would go along the creek bottoms and develop those areas first. The water was readily diverted. They would dig ditches by shovel and let the water run wherever gravity would take it. They were able to develop these bottom lands, which got people excited. The gal in this picture was, obviously, very excited about what she was doing. Water was a way of life. There are stories written by people who passed through this early Greeley. They wrote that these people were completely preoccupied with irrigation. Whole families would be out there doing just that. The kids had a little garden. They played with water. It was a big part of the way of life. As time went by, the projects got bigger and bigger. People pulled together and became more elaborate with some of their projects. At first, two or three

people would come together and build a ditch system. Later, more and more people would join and build larger systems. The payoff for their work was shares in the ditch system that allowed the use of the water running through it. You can see, from the pictures, that many people worked very hard to create some of these first irrigation systems. Finally, they graduated to using teams of horses and oxen to finish some of these large irrigation projects. As these systems grew, they extended out, not just on the bottom lands, but onto the bench lands, and they ended up cultivating large areas. A vast area, compared to what we knew earlier, is in cultivation today. They brought water to the land and it was a big part of the process that formed Colorado.

Today, as we are sitting here, we have even more elaborate projects. We irrigate over 1 1/2 million acres of land and support 2 to 2 1/2 million people along the South Platte River. Quite different from our start, but it shows you our beginnings and where we are now.

These people found that when they started irrigation, they changed the hydrology of the system. When they first came west, the Platte River and the major tributaries had high flows in the spring, May and June, associated with the snow runoff. However, they found that, as they started developing these irrigation projects, the flows were sustained longer into the summer. The places east of Greeley that were originally very dry in the summer, July, August and September, started showing flows later in the season, as the irrigation developed. The return flows percolated through the vadose zone and along with surface return flows built up the water table and enhanced the base-flow of these rivers. As irrigation developed, people used this water more and more in a downstream manner, and developed the system we have today.

Next, let's examine water rights on the South Platte and its tributaries; what are their priorities; and how did they get started?

Beginning along the foothills area, some of the earliest priorities can be found in that area. The 1859, 1860-1865 priorities exist in the upper reaches of the Poudre River, Boulder Creek, and Clear Creek. That is where irrigation began. The return flows or trickle down effects, so to speak, created the ability for people downstream to use water, and created a more reliable water supply.

As we look from Denver to Greeley, the majority of those active water rights have appropriation dates between the late 1860's and early 1870's. If you do not have an 1875 water right between Denver and Greeley on the South Platte, it is likely that you do not get water part of the year.

From Greeley to Fort Morgan/Sterling area, those water rights have appropriation dates between the late 1870's and the late 1880's. Again, water was becoming available to them in June and July and was more reliable as a source to grow crops.

Lastly, if you go from Sterling to the Nebraska state line, those priorities are between the 1880's and 1890's. Nebraska is treated as an 1897 water right. That is when the water became available and usable at that location. We have seen this progression of water rights as water has become more reliable and more available as the hydrologic system changed.

Even before 1900, direct-flow rights were over appropriated on the South Platte River. In other words, there were more water rights than there was water during parts of the year. Therefore, the capibility to store water for use during the dry season was necessary. The next phase of development involved reservoirs. Many reservoirs developed between 1890 and 1920. Barr Lake has an 1885 water right and a 1909 water right for storage. Many of the plains reservoirs were constructed just after the turn of the century, between 1900 and 1920. Many of the Upper Basin reservoirs are from the same era. The goal in reservoir development was to change the hydrologic pattern to take the high flows during snow-melt runoff storms and use them for supplemental water supply later in the year. Again, this tended to create a more stable base flow and year-around running river on the South Platte and its tributaries.

Another phase of development was trans-mountain diversions, they have been added since before the turn of the century. The Grand River Ditch on the Poudre river was started before 1900. The Colorado Big-Thompson system was developed in the 1950's. Denver's system, including the Moffat and Roberts tunnels, was designed to bring water over from the west slope. These tunnels were developed during the 1940's, 1950's, and 1960's. Currently, we transport over 400,000 acre-ft a year from other basins into the South Platte. These waters support this system that we have developed over the years.

Wells are another developmental period. There were a few hand-dug wells around the turn of the century. Droughts encouraged well drilling, especially the drought of the early 1950's. We had several thousand wells were installed during that era in efforts to offset the drought conditions. There is a large underground reservoir in the alluvium under the Platte River; it has been estimated to contain approximately 14 million acre-ft. At that point in time, irrigators said, 'that is where the water is, so let's go after it.' Since then, we have changed our water laws so that wells are in the same priority system as all other water rights. The wells are very junior water rights, therefore, we have to come up with other schemes in order to allow the wells to continue. There has been very limited irrigation well development since 1970.

That brings us to today, where water transfers are the major activity. We are trying to move water from irrigation to municipal and industrial uses in order to preserve priorities and secure reliable sources of water.

This discussion gives an idea of where we have been and how we have developed over the years to get to where we are now. We have developed a vast system of irrigation. We have developed large cities with large expanses of green belt. That is a part of the definition our ecological system on the Platte River.

That brings us to the institutional practices that we, as water managers, are involved with as we look at water rights, and water right transfers. I think that there are several practices we must examine in the future to enhance and preserve our ecological integrity. First is cooperation among cities in developing water supplies. We need to look at integrated projects, rather than individual projects, which may be less efficient and have larger ecological impacts. The governor has encouraged integrated projects over the past few years. Hopefully, people will continue to pursue this integration.

For the South Platte River, trans-mountain diversions, with compensatory provisions, may be more reliable than drying up vast areas of irrigated land. We have seen how trans-mountain diversions impact our region, especially in the northern areas of the Poudre where the Colorado-Big Thompson project has made life different. These are options that we need to examine.

Reusing developed water may be a viable option to keep some of our irrigated areas, and some of our green belts alive. This is one of the concepts proposed by Thornton. Thornton would like to use developed water, and then send the return flows back up to the Poudre area so that it can be used to maintain some of the agriculture that existed previously.

The leasing of water from irrigation uses to municipal uses during droughts may reduce the impact of permanent dry-ups. There are some definite possibilities within this option, especially for the Metro area. There are many practices that can be used to enhance and maintain our ecology.

We need to avoid lining canals, and changing canal conditions that have established wetland habitats. There are many ecological systems involved with our irrigation works and we need to preserve those when possible.

Many existing storage facilities can be repaired rather than building new ones. We have, I think, 782 dams in this division along the South Platte. Many of them have been restricted by our office because of safety problems. Some efforts to rebuild these dams will allow some more storage and be more acceptable than building new storage.

The utilization of some of our existing facilities could be increased. Chatfield Reservoir may be a good example. We have a conservation pool there, and above it, approximately 17,000 acre-ft, that could be used for water storage. It is no longer needed for flood control. That water could serve the many varied interests in the Metro area. There are people who would like to raft down the metro corridor at times. We may be able to provide pools for the people who would like to see minimum flows in the area, and cities who would like to see more water for dilution purposes to enhance the water quality at less cost. The Denver Metro Wastewater Treatment Plant experiences times in August and September when they could use more water for dilution of their effluent. Everyone knows that the water users below Denver would never complain about receiving a little more water during the year. You can see there are some options that might help provide for the varied interests.

We need to reexamine some of the recharge areas. We might be able to create new wetland habitats, increase return flows, stabilize groundwater tables and, possibly stabilize some of the flows along the Platte River. Recharge activities have developed greatly over the last ten years. I think in the last several years we have been artificially recharging about 50,000 acre-ft of water per year into the alluvial aquifers, which has also created some wetlands. The Division of Wildlife has some prairie ponds near Brush, which have benefitted that area. I think there are more areas along the Platte where we can make this happen. We will have to examine the pros and cons of the situation but it does look promising for some areas.

We may have to establish minimum stream flows in critical areas. The city of Boulder has done this. Developing new water rights may work, or there is the option of buying old water rights. If the situation is important, some of these options may be necessary. We may have to look at limitations on the extent of exchanges that dry up river reaches. Those are some of the relationships which must be considered.

Finally, we might look at managing municipal effluents. We have seen land application. The city of Aurora irrigates golf courses with effluent. Budweiser, east of Ft. Collins, uses their effluent to irrigate some sprinkler circles in the area.

We might look at utilizing wetlands for water treatment, and minimizing return flow impacts. Some of you may be familiar with Barr Lake. When I was growing up, it was considered a big cesspool. No one wanted to get near the lake, touch it, or swim in it because most of the Denver effluents were going into Barr Lake. That situation has since changed, and Barr Lake has improved and been turned into a State park area. It has become a refuge for birds, and is considered a positive impact on the area. A similar thing has happened to Clear Creek. The Coors plant, in Golden, has been instructed to not let their effluent enter the Croke canal, which leads to Stanley Lake, in order to protect that municipal water supply. Instead, it goes down the river and is stored in lined gravel pits. Later in the year, when conditions are amenable for better quality water upstream, the water is exchanged back upstream.

Those are some of the options that we can look at. Some may be feasible, others may not be. We may have to evaluate the pros and cons on a case by case basis. These are practices that water managers can be aware of; and, hopefully, by being aware of these practices, they will have a broader understanding of ecological integrity, necessary to improve the system within the South Platte.

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Media and Ecology

Ed Marston

Editor, *High Country News*

In thinking about this talk, I came to realize that my specialty is that I am a generalist. As a result, this talk has no footnotes. You will often hear people say, "The West was fascinating back in the late 19th century. That is when the region was historically significant; that is when everything we do now was laid down." I disagree. It is my sense that our era is every bit as exciting, if not more so, than the late 19th century. There are people who are here today who are going to say someday: "I wish I had been *alive* then, instead of just being there." Today, I would like to tell you why I think our times will - 100 years from now - be seen as both exciting and historic.

My perspective comes from my position with High Country News, a paper that pretends to cover the 10 western states, about 1 million square miles. We are free-lance driven. We have a couple of hundred free-lance writers out there, and when they think that something important has happened in their region, they call us.

The lead story in the present issue is the end of underground nuclear testing at the Nevada Test site. It has received relatively little publicity. President Bush traded it away for his beloved Superconducting Supercollider. That was the deal. The liberals get a moratorium on nuclear testing and Texas gets a big chunk of scientific pork. Senator Hatfield of Oregon, who was one of the first U.S. soldiers to land at Hiroshima or Nagasaki, I'm not sure which, after World War II ended, was a driving force behind this moratorium on underground nuclear testing.

Looking at this audience, I realize that may not mean a lot to many of you. But I grew up in the 1950's reading something called *I.F. Stone's Weekly*. I.F. Stone had a little newsletter out of Washington D.C. He died recently and got a fair amount of publicity because journalists loved him. He spent the 1950's and 1960's exposing what the Atomic Energy Commission was doing to people. He wrote about the Downwinders; he wrote about strontium-90 in milk supply. He wrote about the various cover-ups. Back then he made public the exposure of soldiers to nuclear testing, and all the other abuses that have come out over the years.

This is a free country; he could write about these things but, of course, nothing happened. It was not picked up by the mass media. The Congress did not react. It seemed to me as a kid, as a teenager in the 1950's, that was the way the world was. There was this enormously powerful nuclear bureaucracy and defense establishment that was going to do what it wanted. And then there were the critics, on the fringes, who were going to criticize and expose, but nothing would happen.

So, today, I am amazed to have lived through the nuclear age, and to be alive at a time when nuclear testing, at least for the next nine months, is over in the United States. And at a

time when almost certainly the whole defense mechanism that we have set up in the West -- Los Alamos, Livermore, Hanford, INEL, and Rocky Flats -- are being dismantled. Hundreds of thousands of jobs, billions of dollars, an immense investment is just being taken apart. One enormous Western domino is falling, in part precipitated by the USSR and by its dissolution.

Another falling domino is the election last week, or the week before, of an avowed environmentalist to head up the Metropolitan Water District. In a way, the Metropolitan Water District is to the inland rural West what the USSR was to the democracies. If you follow local water boards like the Colorado River Water Conservation District, their USSR is California. I predict that with the fall of MWD, and with its conversion to efficiency and ecological integrity, our water establishment will follow eventually. That is because when your enemy starts becoming rational, you are forced to become rational. It shows just how diabolical California is.

The defeat of Two Forks Dam is another example. The death of that project is driving all sorts of events in Colorado.

The bill that I think is still on Bush's desk, and as far as I know he hasn't signed it or vetoed it, is that omnibus Water Bill. That bill includes a reform of California's Central Valley Project. Eight hundred thousand acre feet of water from that immense California project will go to fishes and birds. It is incredible that despite the strong opposition of the California growers, of California's governor, and of one of California's senators, Bush signed the bill.

The Central Utah project is another title in that bill. The newly configured Central Utah project is very different from the old project. It only passed the Congress because of cooperation between the water developers and the environmental community. If the environmental community had taken a walk on that bill, the Central Utah project would have remained an unfinished symphony.

So we now live in a time when the environmental community is shaping water projects.

I also see the recent fall of the president of General Motors, Robert Stempel, as related to the changes I am outlining.

Detroit said that if you force us to produce efficient cars we are going to have big economic troubles. It is hard to believe how much bigger the economic troubles of Detroit could of been, had they been forced to be efficient.

What do these examples mean? Since I am not a historian, I can posit a sort of plate-tectonic theory, that there are fundamental forces driving these events. Let me speculate on what some of these forces are. One that I think is incontrovertible is decentralization. What happened to the Soviet Union is also happening to the Western United States. The Soviet Union's bureaucracies were unable to administer a far-flung colony, and it collapsed. We who live in the West are experiencing much the same thing, in a much slower and more buffered way. The federal government, our centralized bureaucracy, built the

West over a hundred years. It laid out and financed what we do: nuclear weapon labs, logging, dam building, mining, and so on. It has been a 'made-in-Washington' economy that is now collapsing in a slow-motion kind of way. I think that is one part of this.

One of the things that has undermined the centralized control is -- this is corny -- is a growing sense of freedom and independence on the part of the people. I am not a great fan of Reagan and Bush, but the rhetoric of freedom, independence, doing for yourself and not depending on the government, even if it was hypocritically delivered in some cases, had real meaning for people. And we acted on it and we are freeing ourselves. The incredible thing for me was that the West voted the way it did for Reagan in 1980 and then he came in and destroyed the West, if you remember, economically. He killed Carter's synthetic fuels corporation and pushed oil prices down and sent us, at least those of us that live in the rural-inland West, into a depression, the likes of which I have never experienced. It lasted from the early 80's through the late 80's and the community I live in has finally pulled out of that. It emptied out the region. It was an incredible event and it did not seem to interfere with his popularity because he got even bigger margins in 1984. I think we really believed in cutting ourselves loose from that life support system out of Washington.

They used to say that the Soviet Union could not have copiers and FAXes and computer modems because if you let those people freely communicate with each other that would mean the downfall of their system. What was not understood was that the same thing went for the West. I think the defeat of Two Forks Dam was a direct result of modern communications; of the ability to build computer models, water computer models on little desk top computers worth a few thousand dollars. The power the bureaucracies once had over information is vanishing, and anyone today with a little bit of money and a lot of skill can match the centralized administrators in economic and resource analysis. There was good political organizing against Two Forks. But more than anything else, Two Forks was beaten by the Environmental Caucus, a bunch of high-tech environmentalists, who were criticized heavily within the environmental community for bothering with this technical stuff and building a computerized model of the Denver Water System. The other environmentalists said we ought to be out there organizing at the grassroots level, writing letters and lobbying Congress. But instead, the Caucus did their analysis and turned the tide.

The final tectonic force, if you will, is efficiency. Although we always feel on the edge, as if we are squeezing our system for all its worth, I think there is enormous fat in the system. We recently did two special issues on electricity, and people argued over what percent of the electric system you could shut down if off the shelf efficiency systems were introduced. I don't remember the numbers very well, but the industry said -- the Electric Power Research Institute out in Palo Alto, California -- said something like 30%. It said two to three out of every ten power plants could be shut down if we were as efficient as we can be. And Amory Lovins says 80%, 8 out of 10 could be shut down. So why quibble. Let's say only 20 or 30% of all power plants can be shutdown. That is still an enormous ability to use fewer resources. It is an enormous gift. I think so many of our projects, so much of our economic activity, was created to churn the water. It is activity for activity's sake. Now, as this new consciousness about what we are doing to the world becomes more and more clear to us, we begin to look at those activities, and we become better housekeepers, which is really what it is all about.

Automobiles, because they loom so large in terms of using our resources, are fascinating, and there is a book that I recommend to everyone called The Machine That Changed The World: Lean Technology, by a team but headed by a guy named James Womack. He is head of a group of MIT researchers who spent a well-funded decade looking at auto plans all over the world. It has graphs and tables and charts and analysis of every automobile manufacturing plant but, nonetheless, it is the most fascinating book I have read in a long time. One of the things it says is that in a traditional auto plant, Japanese, European or American, something like 30% of the work force and floor space is taken up fixing the cars up after they are built. In a modern plant, a plant that uses lean production, there is no one who works on the car after it is built, and so the plants are much smaller, and have many less staff.

Let me give one example. I had never understood the significance of just-in-time delivery. I thought of just-in-time delivery as a way to control inventory. Just as the assembler reaches for a fender to put it on the car, the guy from the supplier hands him the fender. But Womack, et. al, said that the point of it is not so much controlling inventory, although that was important, as it was making sure that you did not end up with a months worth of fenders that did not fit. It was quality control. It used to be that you would get a month's worth of poorly fitting fenders and you would put them all on whether they fit or not. That is why you had some large percentage of the plant working on the cars after the cars were built. They were putting this thing together that should have never been put together in the first place. That is why -- you know how it used to be -- you would buy a car and while driving it out of the lot and suddenly, with me it was always the dashboard that would always pop up, and in the back the rivets would come out. Reading that book made me believe, since are doing it with automobiles, it made me believe in enormous efficiencies in electricity.

I have spent a lot of time paying attention to ranching lately. One thing that I have become convinced of is the potential for restoring the range, pursuing restoration, riparian areas first, but eventually range restoration in general. The ranchers will have to do it, and as they do it, not only will our streams come back but the watersheds will come back. We are at a place where we are beginning to look at the world anew and the potential for change is just incredible.

One of the things at yesterday's roundtable that I pushed on was that these things we look at, this physical and institutional world we see that seems so permanent, should really be seen as here today and perhaps gone tomorrow.

What we will end up doing, I think, is what I call high-grading restoration. High-grading is a term out of mining. You go into a mine and take the richest ore. It can be a destructive practice for the rest of the ore, but you take out the richest first. Later, you may take the lower grade ores. I think it will be the same way with restoration. What we are going to do is take out the most destructive aspects of what we have already done. I think one of the first dams that is going to come out in this country will be the Elwah Dam in the state of Washington, right on the border of Olympic National Park. It will restore a fishery, it will put an economic floor under an Indian tribe that lives there, and the loss of a dab of electricity will be made up easily through rewinding motors and some simple efficiency steps.

What we did in the past made sense for that time. But now we look at things differently. I say all this because I had the sense -- and maybe it was a misplaced sense -- that while our roundtable was dealing with specialties, everyone was quite comfortable. But then we came up against the whole, we sort of said, "Well, this is impossible". We said, "it's gridlock, there are stakeholders, the stakeholders won't move, the critics will just be nasty and abrasive." My sense is very different. I don't understand how the change occurs, but change is driven by strong forces; it is happening and it will continue to happen. My fear is that this enormous wealth, in terms of using the fat in the old order, restoration and efficiency, changing the way we use the range and so on, will be used up for just more of the same. That we will, for example, continue to suburbanize the West. What I worry about is that while there is this opportunity, we do not have a full vision to replace the old.

I see the West -- and this is my wrap -- I see the West as missing three major institutions to implement these changes, to make them constructive changes.

First of all, we lack -- and this is not a plug for High Country News -- we lack a regional media. There are just a few people out here. The five core states that we cover have 7 million people and more than half of them live in 2 metropolitan areas. And there is no way for these people to communicate with each other. The way we have always communicated, the way Westerners have always communicated, is through the federal agencies and back in Washington. And as that breaks down, as that becomes ineffective, we are going to have to create new ways to communicate, for Wyoming to talk to Colorado to talk to Utah. We do not have the resources, no one State has the resources, to do this by itself. We share common problems, and yet the regional newspapers we once had are retreating. The Denver Post used to set the agenda or at least be able to put its agenda on the tables of everybody in a five state region. The Denver Post used to have more Sunday circulation than all the daily papers put together in Colorado and the four surrounding states. And that, of course, is no longer true. The Denver Post is now the city of Denver's paper and the "region" it covers is Aurora. And it's not just the Denver Post. It is the Salt Lake papers, it's the Boise paper. The only major exception is the Casper Wyoming Star-Tribune, and that's because Wyoming lacks a city. The Star Tribune is forced to cover Wyoming by itself. The other exception, and it doesn't do anyone any good out here, is the LA Times, which has a sense of the region because Los Angeles, I think, has succeeded Denver as the queen city of the West. It is Los Angeles that in a sense is the West's city. It provides the market and the settlers. If you live in a rural area, you know we are being resettled out of southern California. The people in Los Angeles want to know about the West and the LA Times is providing them with that.

The second thing we don't have is a regional university. I associate Harvard with New England, Stanford and Berkeley with northern California. I don't know what university is a particularly western university. I used to think that the universities lacked resources but then, when the Superconducting Supercollider was up for grabs, 5-6-7 years ago, suddenly every Western institution of higher learning put together a few hundred thousand dollars to go chase this thing. And here is the West, with these incredible challenges, and I think the most exciting place in the country, and no one is interested in studying that in detail. I do not mean no one, every institution has professors who really care about this region and maybe if you put them all together you would have a critical

mass. But everyone, University of Arizona, Montana schools, everyone put together fat proposals to get the Superconducting Supercollider, while these institutions continued to ignore the West.

The third thing the West lacks is a citizen reform. I'm an environmentalist, the High Country News covers the West on behalf of the environmental community, but the environmental community still cannot see people and communities and industries. Until the environmental community somehow takes into its heart people and human issues, it cannot play the role of a reform movement, a deeply rooted reform movement, the way, let's say, you had in the cities at the turn of the century, citizen reform groups that did away with child labor, that made plumbing compulsory in homes, that upgraded the cities. We don't have that yet, we don't have that integration of a concern for the environment and a concern for people. I think that is because the fight is still seen as a zero sum game that will take from one and give to the other.

Just in case I have not been obvious enough, I think many things are possible, including many of the things we think are impossible. I think we are moving almost too quickly, that the collapse of the old order is occurring too quickly for us to create the new order. When I came here twenty years ago, there was so much consensus I thought I would suffocate. There was no room for people with different perspectives. That was the consensus that built the West the way it is. And now that old order is collapsing, big chunks at a time, and yet we don't have the vision to put in its place.

There is my real fear. The nuclear scientists and administrators and doctors who came west were really mandarins. They were elites, and they moved into this region and I think they betrayed the people who most believed in them. For those who don't know the stories, they are horrible: dusting of sheep herds in Utah with bomb fallout, the pollution of aquifers, the exposing of the soldiers. There is a whole litany of it, and then the cover-ups. Some of the cover-ups were just bullying and appeals to patriotism and to national security. And it was done because this nuclear elite, the scientific and administrative elite, had two wonderful principles that they were after. They were idealists of the highest order. They were after energy too cheap to meter, and not only energy too cheap to meter, but the bombs were going to do wonderful things: they were going to turn impermeable, natural gas deposits into permeable gas. They were going to dig harbors in Alaska. They were going to dig a new Panama canal. I mean this was a wondrous tool. For those of you who are in your twenties and thirties, those early dreams may seem like pie in the sky, but back then they were real. And the other thing they were going to do, is defeat Godless communism. So they were these twin ideals, twin dreams, and they were so important that people did not matter much. And so people were abused and betrayed and sickened. And I think this fall of the nuclear establishment is the result.

What I fear is that the environmental community in pursuit of wonderful ideals, will also betray people. Not deliberately betray people, as I don't think the nuclear people meant to. They were after something so important that they could not bother with Utah shepherds.

Thankyou very much for your attention.

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South Platte River Observations: Historical Clues to the Evolution of a River's Ecology

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ABSTRACT

The South Platte River begins high in the Colorado Rockies, emerging from the foothills of the front range southwest of Denver. From here the river flows in a general northeasterly direction across Colorado's high plains before leaving the state and entering Nebraska. During the nineteenth century, that portion of the river which traverses the high plains was explored by both Stephen H. Long and Charles C. Fremont. The river also became one of the primary routes (the "Denver Road") to the Colorado gold fields during the 1859 Pikes Peak gold rush, and later for pioneers, settlers, and the railroads. Eventually the river's water was stored and used to irrigate crops in the South Platte Valley. Throughout Colorado history, the river has been both praised and cursed. Early descriptions have ranged from "treeless," "sandy," and "barren," to "[a] beautiful river in whom the thirsty finds a true friend." Many nineteenth century explorers, gold-seeking fifty-niners, pioneers, and farmers encountered the South Platte River and described it in detail. These descriptions, albeit unintentionally, often provide clues to the ecological nature of the South Platte River as it began to evolve during the last half of the nineteenth century.

Introduction

The Clean Water Act of 1972 is currently awaiting amendment and reauthorization by the United States Congress. Section two of this legislation, now in the hands of the Senate, lists as one purpose of its reauthorization: "To assure that water pollution control programs more comprehensively protect the *ecological integrity* (emphasis added) of waterbodies, including the maintenance and *restoration* (emphasis added) of aquatic habitat, through enhanced protection of the physical and biological components of waterbodies."[1] This statement raises important questions. What exactly is "ecological integrity," and to what extent will aquatic habitats be protected and "restored?" These questions are particularly relevant when applied to the South Platte River in northeastern Colorado. For here is a river which has been substantially altered by human activity over the past 100 years. How will reauthorization of the Clean Water Act affect the South Platte basin? To help answer this, it is necessary to examine the river's history and evolution over the past 130 years.

The South Platte River has its source high in the Colorado Rockies northeast of Fairplay, emerging from the foothills of the front range southwest of Denver. From here the river flows first northward along the front range, then in a general northeasterly direction across Colorado's high plains before leaving the state and entering Nebraska. Six major tributaries join the South Platte along the eastern base of the front range: Bear Creek, Clear Creek, St. Vrain Creek (and its major tributary Boulder Creek), the Big Thompson

River, and the Cache la Poudre River. The South Platte drains an area of over 24,000 square miles, and is approximately 422 miles in length.[2]

In the mid-nineteenth century large stretches of the South Platte River valley in northeastern Colorado were treeless, and described by phrases such as a "miserable country," one of "alkali soils" and "unvaried sterility." The earliest observations of the South Platte reveal a river which could be a raging torrent one year, and a dry sand bed the next. The South Platte and its tributaries which rise in the mountains, have their greatest discharges in the late spring and early summer from melting snow. Summer thunderstorms also add to the flow, and occasionally can cause disastrous floods. Historically intermittent, today the South Platte is a perennial river with a much more predictable flow than 130 years ago. While this predictability and meticulous regulation are controversial, the South Platte's riparian habitat across Colorado's high plains is in part a direct result of human influence. Over the past century the development of irrigated agriculture within the South Platte valley has created a greater and more constant flow of water in the river, due in large part to irrigation return flows, water storage, and transmountain water diversion.

Exploration

The earliest anglo-American scientific exploration to ascend the South Platte and record observations along its route was that of Steven H. Long in 1819-1820. This scientific expedition was part of a larger plan conceived by John Calhoun, Secretary of War under President James Monroe. Calhoun wanted to enlarge American power and influence in the West. Prior to this trip, however, in 1803 Thomas Jefferson sent Lewis and Clark to explore the wilderness northwest of St. Louis along the Missouri River and across the Pacific Northwest, and in 1806-1807 Zebulon Pike crossed the central plains along the Arkansas River.[3] Although the Pike expedition explored the headwaters of the South Platte in the vicinity of Fairplay, neither he nor Lewis and Clark saw the lower South Platte, and it was not until 1820 that the river valley was first described by Edwin James of the Long expedition. James, the official botanist and geologist for the trip, wrote what is probably the best account of the expedition. His first description of the Platte River in Nebraska is revealing:

> The Platte, called by the Otoes Ne-braska, (Flat river, or water,) is, as its name imports, almost uniformly broad and shoal. It is fordable at almost any place, except when swollen by freshets [sic], which occur in the Spring season, from the melting of snow, and occasionally during the other portions of the year, from excessive rain. Its bed is composed almost exclusively of sand, forming innumerable bars, which are continually changing their position, and moving downward, till at length they are discharged into the Missouri, and swept away to the ocean by that rapid and turbulent river.[4]

Edwin James foretold what the Long expedition, and others that followed, would find on the South Platte. Although not officially designated un-navigable until years later, James' early descriptions predicted this about the South Platte as well.

The Long expedition made slow but steady progress up the Platte, keeping a wary eye out for Pawnee Indians, finally reaching the confluence of the north and south forks on June 22, 1820. James noted that the South Platte "is about nine hundred yards wide, and very

rapid, but so shoal that we found it unnecessary to dismount from our horses, or to unpack the mules [in order to cross]."[5] As a trained geologist and botanist, James described the land formations and scenery as the expedition progressed:

> Intermixed in the narrow fringe of timber, which marks the course of the river, are very numerous trees, killed by the action of the beaver or by the effects of old age, their decorticated and bleached trunks and limbs strongly contrasting with the surrounding objects, many of them rendered doubly interesting by affording a support to the nests of the bald eagle, elevated like a beacon in the horizon of the traveller.[6]

Here James makes note of a narrow fringe or timber, but as this next passage demonstrates, the South Platte valley included both wooded areas along the river and more barren stretches in 1820:

> We passed several extensive tracts nearly destitute of vegetation. The surface of these consisted entirely of course sand and gravel, with here [and] there an insulated mass of clay, highly impregnated with salt....Some extensive portions of the immediate bottom land, along the river, were white with an effloresced salt.[7]

In early July the group finally caught sight of the front range of the Rockies on the far western horizon. James described the group's first glimpse of the mountains, capturing some of the excitement and awe that must have gripped them at that moment:

> No inequality occurs in the surface of the subjacent country on the east of the mountains, so that our view was wholly unobstructed. They stretched from north to south, like an immense wall occupying all that portion of the horizon, lying to the northwest, west, and southwest. We could now see the surface of the plain, extending almost unvaried to the base of the first ridge, which rises by an abrupt ascent above the commencement of the snow.[8]

As the group continued west towards the Rockies, James made additional significant observations:

> As we approached the mountains, wood became much more abundant along the [South] Platte. We had often heard our guide, in speaking of the country, two or three days journey from the mountains, mention the *Grand Forest*, and were a little surprised on arriving at it, to find no more than a narrow but uninterrupted strip of timber, extending along the immediate bans of the river, never occupying the space of half a mile in width.[9]

Why were more trees observed along the South Platte as the Long expedition continued upstream? One of the most obvious answers is that during some years, the flow of the South Platte was sufficient to sustain the river across all of Colorado's high plains. But during times of drought, the river's flow must have sunk into an aquifer below its bed far upstream from its confluence with the North Platte, leaving a large portion of the riverbed dry. This was in fact the situation when Charles C. Fremont ascended the South Platte in 1842. One other possibility could be that the gigantic herds of bison on the high plains avoided this upper plains portion of the South Platte, saving the riparian vegetation from being consumed or trampled.

Another explorer, David Meriwether, was in the vicinity of the South Platte shortly after the Long expedition. Meriwether went up the Missouri River in 1819 under contract to

Colonel John O'Fallon, and eventually spent the winter of 1820-1821 on the plains. When the weather became quite cold and the snow too deep for travel, Meriwether and his companions ascended a steep hollow along a creek, which they concluded was a tributary of the South Platte. Here they found wood for fuel to last the winter and a fresh water spring:

> After a while we came to a stream running in a northeasterly course, which we concluded was a tributary to the South Fork of the Platte River. Here the weather became so cold and the snow so deep, that we concluded to seek a proper place and camp for the winter. So, ascending a steep hollow where we saw there was wood, we found a shelving rock which projected....Knowing that a spring never freezes, and there being sufficient wood for fuel, we determined to make this our winter camp.[10]

Meriwether's group built a makeshift shelter using saplings and animal skins, and remained there until February of 1821, when they descended the Platte valley to the villages of the Pawnee. Meriwether's comments are significant because they illustrate that a plains tributary of the South Platte could be fairly well timbered.

Following the experiences of the Long expedition and Meriwether, nearly 22 years elapsed before another anglo-American expedition surveyed and explored along the South Platte River. By 1842, public interest in Oregon and the West necessitated additional investigation of the country beyond the Missouri River. John C. Fremont, a lieutenant in the Corps of Topographical Engineers, was chosen to survey the area and contribute to the limited knowledge of the territory. Two of Fremont's most important expeditions occurred in 1842 and 1843-1844. The first extended west to the Wind River Mountains in present-day Wyoming. Like the Long expedition, Fremont reached the forks of the North and South Platte by ascending the river through Nebraska. He described the forks upon reaching them on July 2, 1842:

> The stream here is divided by an island into two channels. The southern is four hundred and fifty feet wide, having eighteen or twenty inches water in the deepest places. With the exception of a few dry bars, the bed of the river is generally quicksands, in which the carts began to sink rapidly so soon as the mules halted, so that it was necessary to keep them constantly in motion....
>
> The northern channel, two thousand two hundred and fifty feet wide, was somewhat deeper, having frequently three feet water in the numerous small channels, with a bed of coarse gravel....We encamped at the point of land immediately at the junction of the North and South forks. Between the streams is a low rich prairie, extending from their confluence eighteen miles westwardly to the bordering hills, where it is five and a half miles wide. It is covered with a luxuriant growth of grass, and along the banks is a slight and scattered fringe of cottonwood and willow.[11]

Although Fremont's principal objective was to survey the north fork of the Platte, he decided to ascend the south fork to obtain astronomical positions, and to locate the mouths of the river's tributaries as far west and south as St. Vrain's Fort:[12]

> Our general course was southwest, up the valley of the river, which was sandy, bordered on the northern side of the valley by a low ridge; and on the south, after seven or eight miles, the river hills became higher. Six miles from our resting place we crossed the bed of a considerable stream, now entirely dry -- a bed of sand. In a grove of willows, near the mouth, were the remains of a considerable fort, constructed of trunks of large trees....The timber appeared to have been much more extensive formerly than now. There were but few trees, a kind of long-leaved willow, standing; and numerous trunks of large trees were scattered about on the ground....Ten miles

> farther we reached the mouth of Lodge Pole creek, a clear and handsome stream, running through a broad valley.... A few willows on the banks strike pleasantly on the eye, by their greenness, in the midst of the hot and barren sands.[13]

Fremont's descriptions, like James', emphasize the sandy, hot, and barren nature of the lower South Platte, and the scarcity of trees. Unlike the Long expedition, however, which found the river flowing throughout its course across the high plains, Fremont was less fortunate. On July 7, 1842, Fremont wrote:

> The sun was getting low, and some narrow lines of timber four or five miles distant promised us a pleasant camp, where, with plenty of wood for fire, and comfortable shelter, and rich grass for our animals, we should find clear cool springs, instead of the warm water of the [South] Platte. On our arrival, we found the bed of a stream fifty to one hundred feet wide, sunk some thirty feet below the level of the prairie, with perpendicular banks, bordered by a fringe of green cottonwood, but not a drop of water. There were several small forks to the stream, all in the same condition. With the exception of the Platte bottom, the country seemed to be of a clay formation, dry; and perfectly devoid of any moisture, and baked hard by the sun.[14]

In 1842 the South Platte was an intermittent river traversing a harsh land. Perhaps the mountain snowpack of the previous winter had been sparse, providing little spring runoff. Whatever the reason, Fremont found the lower South Platte dry in the summer of 1842.

Like Edwin James of the Long expedition, Fremont noted the increasing expanse and lushness of the vegetation as he ascended the river's course:

> Since leaving the forks, our route had passed over a country alternately clay and sand, each presenting the same naked waste. On leaving camp this morning [July 8, 1842], we struck again a sandy region, in which the vegetation appeared somewhat more vigorous than that which we had observed for the last few days; and on the opposite side of the river were some tolerably large groves of timber.[15]

And from Fremont's July 9, 1842 entry:

> From the place at which we had encountered the Arapahoes, the Platte had been tolerably well fringed with timber, and the island here had a fine grove of very large cottonwoods, under whose broad shade the tents were pitched.[16]

As previously mentioned, the observations of both James and Fremont support the possibility that the more lush riparian vegetation along the upper portions of the South Platte nearer the mountains was due to geography. Here, near the mountains, the river's flow was much more likely to be perennial, even during dry years, than further downstream.

Fremont's second expedition (1843-1844) extended west to Fort Vancouver on the Columbia River, and returned by way of Northern California and the Great Basin. In June of 1843 Fremont headed west from Missouri up the Kansas and Republican watersheds, reaching the South Platte valley on June 30, 1843. This year Fremont noted changes in the river:

> Crossing the summit of an elevated and continuous range of rolling hills, on the afternoon of the 30th of June we found ourselves overlooking a broad and misty valley, where, about ten miles distant, and 1,000 feet below us, the South fork of the Platte was rolling magnificently along, swollen with the waters of the melting snows.[17]

And from a journal entry on July 21, 1843:

> There is a difference in weather compared to last year. The water in the rivers is so high that the crossing causes great delay. The same streams were hardly knee deep last year.[18]

Both of these observations of the South Platte in 1843 indicate a high water year, in stark contrast to the previous year's conditions. Fremont recognized the unreliable and erratic nature of the river in 1843, which was dependent upon the whims of Mother Nature. Historically, the South Platte has had a tremendous annual variation in flow.

Gold Rush

In July of 1858, three brothers from Georgia discovered gold on Dry Creek near present-day Denver. The pocket they placer-mined produced several hundred dollars worth of gold dust before it ran out. News of the small discovery spread quickly, and spawned one of the largest migrations in Colorado history.[19] The following summer brought gold-seeking "fifty-niners" by the thousands to Colorado with their slogan "Pikes Peak or Bust." Many of them and the pioneers and settlers who soon followed entered Colorado along the "Denver Road" through the South Platte valley. Some of them described the South Platte in journals, diaries, and letters. Guidebooks to the Pikes Peak region were quickly published for travellers bound for the Rockies. One such book published in 1858 was entitled *The New Gold Mines of Western Kansas*, written by William B. Parsons. Widely used, it became known simply as "Parsons' Guidebook." Of the South Platte route into Colorado it had this to say:

> Grass is not very abundant beyond Kearney on account of the vast number of animals which passed over the road....There is no wood of any account between O'Fallen's Bluff [near the confluence of the North and South Platte] and Fort St. Vrain. Water will be found without much difficulty the whole way.[20]

This description of the South Platte is significantly different than previously observations. Parsons reported little grass and no trees along much of the South Platte. He also insinuated the availability of water along the route. But from Long and Fremont's experiences, this would not have consistently been the case. In fact, the accuracy of many contemporary guidebooks to the goldfields of Colorado of that era is questionable.

One of the many gold-seekers to travel up the South Platte in 1859 was M. O. Morris, an Englishman headed for the Rockies. His observation of the South Platte reflects that of many other fifty-niners:

> I took the opportunity of walking across the Platte, which here [in the vicinity of Julesburg] is from a quarter to half a mile in width, and rapid in parts; it gives the idea, with its shifting currents and sand spots, of a tide receding from a broad strand...there was a pretty view of the Platte, which extended into a basin and was studded with green islets, quite as pretty...as the 'thousand islands' on the St. Lawrence.[21]

In the nineteenth century prior to irrigation and water storage, the bed of the South Platte was relatively wide, shallow, and braided. With human interference over time the flow of the river became more perennial, and the river bed and channel narrowed.[22]

Between June and August of 1862, Emily Malone Raymond and her three young children traveled with a small wagon train across the plains to meet her husband in Denver. Although the trip was difficult, particularly for a woman with children, Raymond found time to keep a diary of the journey. Her observations on the lack of trees along the South Platte tend to support those found in Parsons' Guidebook:

> Sunday August 3, 1862: We have seen today the first trees since we crossed the river and they were so rare a sight....We had to travel till after dark to find a good camping ground.[23]

Other travellers both echoed and contradicted some of these observations. A newlywed couple, Mr. and Mrs. Thomas Tootle, ascended the South Platte valley in 1862 on their honeymoon trip to Denver. Mrs. Tootle kept a diary of her travels, and recorded these passages:

> There is no timber in the Platte valley, all the wood is obtained from the islands in the river...the Platte [is] studded with islands of all sizes from 1 yd. to 1 or 2 miles long, come covered [sic] with high grass and all have trees, some evergreen....The Platte though from 1 to 1 1/2 miles wide is nowhere more than 1 to 4 ft deep. It has more islands than any river in the world. We counted 7 just in front of us in a few hundred yards. In other places I counted 40 or 50 in a small distance....Came to Bijou Creek this morning and found the first timber for 8 days.[24]

Tootle's comments mirror earlier observations concerning the river's width, braided nature, and lack of available wood.

After the initial gold rush of 1859, Colorado became a source of interest to many people in the eastern states. As word of Colorado's mountains and natural beauty spread, writers and newspaper columnists came west to describe the country to eastern readers. Bayard Taylor was one well-known travel-writer of his time. His book *Colorado: A Summer Trip* (an account of Taylor's summer travels through Colorado in 1866) was a result of letters originally published in the *New York Tribune*.[25] While in Colorado, he wrote this of the lower South Platte approximately 80 miles west of Julesburg:

> Daylight revealed the Platte on our left -- a narrow, winding, muddy stream, with no timber on its banks. On either side the same bare, brown plain rolled away to the horizon....There is little to see beyond the fact that no part of this region is naturally a desert...where there was timber it has been destroyed [for firewood].[26]

Taylor's remarks also support the thesis that many of the trees in the South Platte valley were cut during the 1859-1860's gold rush and heavy use of the "Denver Road" along the river.

Irrigation

With the discovery of gold in the Rockies and the resulting settlement at Denver, came some of the earliest attempts at irrigation in the South Platte valley. There is evidence that irrigated agriculture was practiced before this at some of the forts along the South Platte (Fort St. Vrain), but as James Michener wrote in *Centennial*, irrigation in the early 1860's was in response to the food needs of the early mining camps, and quickly surpassed any earlier attempts.[27] In the U.S. Patent Office Report on Agriculture of 1861, a chapter entitled "Territory of Colorado: Its Soil, Its Climate, Its Mineral Products and Resources" stated:

> The results of numerous irrigating enterprises during the past season, if for gardening purposes soley [sic], were not only most gratifying but immensely profitable. It was ascertained that in the wide bottom lands of the [South] Platte River and other streams near the base of the mountains, there was a rich alluvial deposit, which only required water at long intervals to promote an astonishing vegetable growth.[28]

Early pioneers recognized their dependence upon irrigation for successful agriculture, and thus began the development of irrigation in the South Platte valley, the digging of the first canals, the development of the agricultural colonies at Greeley and Longmont, and the further development of Colorado water law and the concept of prior appropriation.

Henry M. DeVotie first came to the South Platte valley in 1864. He bought a farm north of the La Grange schoolhouse near Greeley in Weld County around 1870. Some of his recollections in March of 1918 provide additional insight into the early history of the river:

> In 1864 when I first came here it was the fall of the year. My recollection is that the Platte river at that time, after we got above Julesburg it was practically dry for a good many miles; there was plenty of water standing in holes along the banks for culinary purposes and for stock, and along the edge of the islands we didn't have trouble in getting water for stock. I crossed the river once or twice and as I recollected there were places where no water was running....
>
> When we came up in 1864 we used to meet parties going down and camped with them. They told a good many times that the Platte was dry up above, and by the time we got up there we might have trouble finding water....They said the river was practically dry up in Colorado. Along in the fall the parties we saw told us the river used to go dry, from Julesburg up; the general talk was, among the men we met, that all the lower Platte in Colorado would go dry....
>
> When we came up the river later in 1866 I think there was plenty of water for all our necessities. There was water running everywhere as far as I remember at the time. After we got up in to Colorado the river was pretty low above Julesburg, but water was running all that season, for the necessities of the caravan; it didn't impress me much; we had water and I didn't think anything about the flow.[29]

DeVotie's comments tend to substantiate the concept of the South Platte as intermittent.

According to records, David Wall, a disillusioned fifty-niner, first diverted water from Clear Creek to irrigate approximately two acres near Golden in 1859. Later that same year irrigation developed on Boulder Creek, and in 1860 on the Cache la Poudre River, St. Vrain, and Lefthand Creeks -- all tributaries of the South Platte.[30] As farmers irrigated, they and others began to notice over a period of years an increase in the volume of water in the stream and river channels at and below the irrigated sections. This was first observed on a local scale between 1885 and 1897. The hydrologic character of the South Platte was beginning to change.[31] The action of irrigation water percolating into and through the soils (seepage) near watercourses tended to raise the underground water table, producing a greater and more uniform flow of water in the river. Louis G. Carpenter, a professor of irrigation engineering at the State Agricultural College in Fort Collins, verified this in an 1896 Colorado Agricultural Experiment Station study of seepage and return waters from irrigation. He concluded that the passage of seepage water through the soil was very slow, taking years for water applied to outlying land to reach the river, and that over time an additional amount of land could be brought under cultivation in the lower portions of the watershed as the action of seepage water continued.[32] Carpenter

concluded in a later study that the South Platte by 1916 was a much more constant river than before the period of irrigation, largely due to water seepage and reservoir storage.[33] This was also confirmed by the State Engineer's biennial report of 1883-1884:

> It is claimed that the flow of water in the Platte River through this district is much more uniform than formerly, which is undoubtedly true, and is due to the effect of the irrigating canals on the stream above, by reducing its flow in the flood season. After high water, its natural flow is increased by the return into the stream of a portion of the water, which is commonly called 'seepage.'[34]

In 1922 Ralph Parshall, a staff member of Colorado Agricultural College, wrote a paper on the return of seepage water to the lower South Platte. His conclusions were similar if not identical to those of Carpenter. He recognized the historically erratic and intermittent flow of the river -- sometimes non-existent during the late summer, and often not favorable for the further development of irrigation. But as larger ditches were constructed, and reservoirs were built to collect the spring run-off, a more pronounced return flow occurred:

> The practice of irrigation, including the use of extended distribution systems, has created conditions which not only tend to maintain a constant return flow, but have apparently increased the river's discharge beyond all expectation....Perhaps no other Colorado stream has such an abundant return flow as the South Platte River.[35]

Development of irrigation on the South Platte below the mouth of the Poudre River occurred much more slowly than on the Poudre, Big Thompson, or St. Vrain due largely for two reasons. First, the extremely low level of water in the river during much of the growing season prohibited all but the smallest irrigated fields. And second, the geography of the lower South Platte necessitated longer and more expensive irrigation canals than those being used on the upper river or its tributaries.[36] The first small ditches on the lower South Platte date from 1872, a full decade behind irrigation development upstream. But as water slowly became available in the lower South Platte due to upstream seepage and return flows, irrigation and canal construction was able to proceed. Beginning around 1879, economic conditions, an influx of outside capital, and the availability of water led to further irrigation development.[37]

Reservoir Construction

This influx of capital initiated an era of reservoir construction on the South Platte, sometimes referred to as the corporate era, and marked the end of most private and individual efforts. With the availability of eastern and foreign capital, the Larimer and Weld Irrigation Company became one of the first ditch companies to organize with outside investment in 1879. In addition to enlarging old ditches and constructing new ones, foreign and eastern investors bought land in the South Platte valley. Since much of the available bottom land along the river was already being farmed, the higher bench lands above the river's flood plain were purchased, and ditches were dug to supply water to them. But as more canals were either constructed or enlarged, water demand all along the South Platte and its tributaries began to outstrip supplies, particularly during late summer. By this same time, farmers and others had begun to notice the surplus of water flowing down the South Platte and its tributaries each spring as the mountain snowpack melted.

Storage of these surplus flows became the goal for agricultural growth and security, and construction of storage reservoirs began.[38]

From approximately 1880 to 1920 an era of reservoir construction flourished in the South Platte basin. Many reservoirs were located in natural depressions and basins throughout the plains region of the South Platte valley. The first constructed was Churches Reservoir near Golden, which is still utilized for irrigation. It is supplied by Ralston Creek (a tributary of Clear Creek), and holds the oldest adjudication storage right (1884) on the South Platte. Today the basin is a patchwork of irrigation storage reservoirs, ranging in capacity from just a few af acre feet (af) to well over 50,000 af.[39] .....

Construction of mountain reservoirs also occurred at this time. Although typically more expensive to construct, they had less water loss due to evaporation and seepage than storage reservoirs on the plains. The best early example is Cheesman Reservoir on the main stem of the South Platte. When it was completed in 1905, Cheesman was the highest dam structure in the world.[40] These reservoirs, particularly those on the plains, not only store a portion of the spring runoff, but according to Parshall (1922), contribute approximately 20 percent of return flow to the river through seepage.[41]

Henry DeVotie reached similar conclusions in 1918:

> When I first went up on the farm, No. 2 Canal was small -- in 1872 -- compared to what it is now. I think we put in about 40 acres; we had a water right and it was almost impossible to get water sufficient to irrigate our crops; the Poudre along late in the summer used to go practically dry down at Greeley here; the ditches that were then constructed took all the water flow of the Poudre and left the stream dry. I had an idea that when No. 2 Ditch was completed it would practically take all the water from the river to supply it....
>
> For a good many years we had a lot of trouble after we enlarged the ditch -- we used to enlarge it every year or two, and in some way the soil absorbed the water. The sun would come out and it would soon dry up again; we think a good deal of the trouble was caused by our inexperience, and another thing was it required probably three times as much water as it does today to irrigate that same land. This has been brought about by irrigation filling the subsoil, and now there is probably more water flowing past Greeley late in the fall, a good many times more, then used to in the early days. I attribute this increased flow to the fact that the water taken out of the river higher up has filled the subsoil, for at first very little found its way back again to the river but after irrigating so many years the subsoil is saturated and a large amount now gets back to the river making the river flow more uniform than ever before. In other words, irrigation not only assists plant growth but serves the purpose of underground storage of water. Later after we got to building reservoirs and turning the flood waters in them it increased the flow here very materially and it will increase still more as other reservoirs are built. It seems to me this same condition is created eastward down the South Platte river from the mouth of the Cache la Poudre.[42]

Water Diversions

In addition to irrigation and water storage, water diversion into the South Platte basin has played a major role in the evolution of the river's ecology. The first transbasin diversion occurred in 1860 near Fairplay. Gold prospectors constructed it and used the water to wash mining ore, but the operation ceased after a short time.[43] One of the oldest continuous

water diversions into the South Platte basin is the Grand River Ditch, which collects water along the high reaches of the Never Summer Range in Rocky Mountain National Park, transporting it by way of La Poudre Pass to the Poudre River. The Water Supply and Storage Company began construction of the Grand River Ditch in 1890, and water was first diverted through it two years later. Today the ditch transports an average of 22,000 acre-feet/year (af/yr) to the Poudre River, and eventually to the South Platte.[44]

By 1922, ten additional transbasin water diversions into the South Platte basin were in operation. For example, Denver's Moffat water tunnel began diverting water from the Fraser River underneath the continental divide to the south fork of Boulder Creek in 1936. The collection system in the Fraser River basin was small at first, but by 1957 had been greatly expanded.[45] The Moffat Tunnel currently diverts an average of nearly 60,000 af/yr to the South Platte basin.[46] The largest diversion into the South Platte watershed is the Colorado-Big Thompson Project, which has diverted an average of 230,000 af/yr since 1957 (NCWCD). This water originates in the Colorado River and is diverted under the continental divide and into the Big Thompson River, eventually supplying water to irrigators and water users in the Poudre, Big Thompson, St. Vrain, Boulder, and South Platte drainages. Today an average total of nearly 400,000 af/yr of water is imported into the South Platte basin. This is approximately 30 percent of the South Platte's annual native runoff. Nearly 95 percent of this water originates in the Colorado River basin. The North Platte basin supplies most of the balance.[47]

Current South Platte River Conditions

The South Platte River in northeastern Colorado is no longer the same river it was 130 years ago. Human activity in the region has dramatically altered many aspects of the river's ecology. The actions of farmers, irrigators, and reservoir companies since 1860 have dramatically changed the South Platte. Some of the results have been positive. The riparian habitat now in existence along the river is more extensive than before the development of irrigated agriculture, and provides important wildlife habitat. And the descriptions of the river by James and Fremont have been interpreted as two types of vegetational communities in a recent vegetation study along the South Platte. The study concluded that 1973 tree conditions indicated wetter soil conditions than existed previously. This suggests that over the past 130 years an increase in the soil moisture has not only increased the number of trees, but the number of species as well.[48]

However, human activity in the South Platte basin has also adversely affected the environment. As the flow characteristics and vegetation along the South Platte have changed, so have the river's channel formation and sedimentation. Meticulous regulation of the river has allowed riparian vegetation to stabilize the river channel, forcing it to become narrower and more sinuous, and restricting the river's lateral movement and dispersion during flooding.[49] And while increased water supplies through reservoir storage and transbasin diversion have added riparian and wildlife habitat to the South Platte basin, this action has de-watered and sometimes adversely affected other watersheds. Finally, although increased irrigation in the South Platte valley has assisted much of northeastern Colorado economically, it has added to the problem of water pollution from irrigation runoff.

Conclusions

As the future of the South Platte River is contemplated, recognition of the South Platte's ecological history over the past 130 years is both necessary and vital to understanding how reauthorization of the Clean Water Act may affect the river. If the "ecological integrity" of the South Platte is to be protected, what kind of integrity should be sought? And if the South Platte's aquatic habitat is to be "restored," then to what kind of condition? Historians can help in answering these questions, but a combined effort is needed on the part of ecologists, botanists, biologists, engineers, geographers, and others to better understand the history and evolution of the South Platte.

Notes

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Roundtable Discussion Summary and Closing Remarks

Robert Ward

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In looking through the summaries produced by each of the six roundtable discussions, and in talking to the facilitators from each table, the one observation that comes out rather clearly is that people enjoyed talking about ecological integrity and using it as a way to connect their discipline to other disciplines. I see that people enjoyed the opportunity to discuss integration of disciplines voluntarily, rather than being forced to integrate quickly to arrive at an immediate, critical, ecological, water-related decision. I also discovered the exact forum for continuing such voluntary dialogues is not clear. We are not quite sure what this forum will be. Yet, in listening to Ed Marston's talk, the need for such forum is building and we are currently seeking it. Who is going to take the initiative in creating the forum or dialogue - a dialogue that is voluntary, that we enjoy, and that we will find very stimulating as we try to blend our disciplines to deal with ecological integrity?

I also heard comments from several of the discussion groups that the results are actually not as important as the process. They feel that simply getting people to talk is a major task and that, as was implied from David Freeman's talk, we need to develop communication among ourselves. Once such communication is established, the results will come. Often we are asked to produce a result and are forced to talk to each other in a setting less than supportive of mutual exchange of ideas. That is where the involuntary nature of our discussion evolves.

Another point came from several people who would like to do more cross-disciplinary work, but find themselves gridlocked by two things: (1) time, just taking care of the day to day tasks of their job/discipline and (2) lack of organizational support. We have all heard the statement from various organizations, "Well, that is not our mission, therefore we can't participate in that activity." This narrow focus of many of our water and natural resource organizations appears to be questioned more today. Maybe our mission-oriented institutions must recognize, as David Freeman said yesterday, the 12-month, or 18-month, or 24-month plan needs to include contributions of staff time towards a dialogue on ecological concepts, within which each particular agency is going to constitute a part. Not everyone is going to be the big player in managing our total ecology - we are going to be partners with many other organizations.

In summary, on this first major point, professionals in natural resource management want to discuss their role in ecological integrity.

A second major point that came out of the discussions yesterday is that there is no consensus on what ecological integrity means. It is too complex of an issue. Definition, however, will be promulgated. The demand for such definition will probably come from Congress. It will be fleshed out by federal government employees in Washington. You will

see a definition of ecological integrity in the Code of Federal Regulations. We will all be asked to implement the definition in our actions. That is a kind of top down approach that was being discussed. The idea of this conference was to see if we could get together as professionals and the public to develop a definition from the bottom up. The roundtable discussions indicated that we probably won't be able to do that because it would be very hard to gain a consensus on what ecological integrity means, unless there is a crisis to force consensus. I pose the question to you: Is a threat of a legal definition of ecological integrity enough of a crisis that we can get together and begin to put information on the table that our representatives can take back to Washington and enter into the debate? Do we have a mechanism, a forum, where we can form a consensus as to what we think ecological integrity might mean? Or, are we going to simply let others carry out the publics' will and define it? We will then have to implement whatever they develop. How do we, in Colorado, want to approach this evolving ecological integrity concept in water management? That's a question I think we all need to ask ourselves.

A third major point that I heard coming out of yesterday's meeting was: Ecological integrity implies function rather than condition. What does this imply? For one thing, it implies that we cannot continue to look at water quality management as we have in the past. The frame of reference needs to shift. Water quality management has tended to be standards and permits that are static and condition oriented; and, if we start dealing with ecological integrity, we are going to start dealing with values, functions, and the dynamic nature of a system.

The next implication is: Are we a part of this system or are we managers of this system? In other words; are we going to control or participate? Viewing water quality management as a part of an ecosystem's function is much different than viewing water quality as a condition to be controlled.

A fourth point that came out of yesterday's discussion was how does the public get involved? How does the public understand the value choices that are involved in ecological integrity? How does the public gain an appreciation to the ramifications of using ecological integrity as a national goal for water quality management? What seems to be of concern is that if we, as professionals, are having difficulty understanding ecological integrity, how can we expect the public to synthesize all the concepts and ramifications? In more general terms, the question seems to be: How do we synthesize what we, as professionals and concerned citizens, do in the environment and make that understood by the public? How do we obtain data from the environment and make that understood by the public? One specific comment I heard at one table was the experience of a person sampling water in a stream and meeting people, quite frequently, who want to know: "Is the water quality better or is it worse?" How does the public get that understanding; how do they know what the status of the environment is? How do they know what the status of the water quality is? How do they know what the status of the ecology is? We need to seriously consider how the public gains its information on environmental quality. Have the environmental professionals even sat down and designed an environmental information system for the public? Who would take a lead in developing public information?

The last point is that as the groups were talking it seemed that the ecological values of the different "players" were more similar than they were different. It seems, as Ed Marston noted, a connectedness is beginning to develop and people are beginning to appreciate such interrelationships. This evolving connectedness has the potential to further develop discussions and, hopefully, some consensus as to what it is we, collectively, are going to do with respect to incorporating ecological integrity into water management. Again though, I would ask, what forum are we, in our diverse disciplines, going to use to carry on the dialogue; and how are we going to get the public involved in these dialogues? Where do we focus, who takes the initiative? Again it gets back to this conference. If you go back and look at the history of this conference, I think you will see that four years ago some very farsighted individuals realized that such dialogues needed to take place. And if you look at the list of sponsoring organizations for this conference, I think that you will begin to see the integration that we are talking about: federal, state, regional, local, as well as across disciplines. So, already, within this conference there is a lot of integration and it is, in fact, creating the forum.

I don't feel like we have developed many answers, but I hope you will take away many thoughts regarding how your own organization can begin to examine its role in ecological integrity. In conclusion, I hope these words have synthesized much of the discussions held yesterday in the roundtable dialogues. That is what we have tried to capture here.

I want to again thank the organizers for the foresight and energy put into this conference.

Thank you all for coming.

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Technical Papers Presented

Determination of Consumptive Water Use by Irrigated Crops using Remote Sensing and GIS Techniques

David G. Wagner, Roger M. Hoffer, and Terence H. Podmore

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ABSTRACT

This paper outlines a method for using multitemporal Landsat TM data and a GIS to model the evapotranspiration requirements of irrigated cropland within the Cache la Poudre River Basin in Larimer and Weld Counties, Colorado. Multitemporal Landsat TM data sets for May, July and September, 1991 were used to derive crop species maps and acreage tables for the river basin. These results are being used as input to a GIS river basin evapotranspiration model. Daily and seasonal evapotranspiration estimates are being computed from the model. The seasonal basin water balance will be computed which includes deep percolation, evapotranspiration, precipitation, surface runoff and basin inflow-outflow. The GIS will be used to study nitrate non-point source pollution in the basin aquifer. This paper describes work in progress which is expected to be concluded in December, 1992.

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Recommended Water Quality Criteria for Agricultural Diversions from the South Platte

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ABSTRACT

Recent years have seen increasing competition between urban/industrial areas and irrigated agriculture for the limited water resources of the western United States. One attempt to ease this tension in Colorado has been through the utilization of agricultural water decrees for urban purposes through augmentation, transfer and exchange agreements. A key requirement of these arrangements under Colorado water law is that water returned to the stream must be of "acceptable quality" relative to historical use. There is a growing concern among agricultural water users regarding the interpretation of what constitutes "acceptable quality." At time, the South Platte River which supplies water for the most productive agricultural region of Colorado, consists almost entirely of secondary-treated sewage flows from Denver. Recently, the city of Thornton has spent more than $50 million to buy water from 114 farms and plans to exchange the city's lower quality South Platte water with farmers to obtain higher quality Cache la Poudre River water. This water transfer probably will precipitate the incorporation of water quality concerns into future water right transactions. Water quality problems resulting from urban wastewater discharges also exist in the Arkansas River basin. If irrigated agriculture is to survive in this competitive water environment, the water quality issue must be better understood, managed and incorporated into water rights doctrine.

There are various constituents that occur in secondary-treated urban waste which may pose environmental hazard to irrigated agriculture. Significant levels of total-dissolved solids, nitrates, pathogenic organisms, and heavy metals are discussed as potential threats.

Other states and countries have established quality criteria for waters used in irrigation. This presentation reports the background for developing agricultural water quality criteria for Colorado and explores the major chemical and biological constituents of interest to Colorado agriculture. Criteria are proposed for each constituent based upon a scientific review of the latest literature.

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Historical and Current Distribution of Fish in Three Ecological Zones of the South Platte River

Joni Nuttle and Ronald French

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ABSTRACT

In Colorado, the South Platte River passes through three ecological zones. These ecological zones are the Montane zone (headwaters), the Transitional zone (between montane and plains) and the Plains zone. The Montane zone of the South Platte River extends from the headwaters in South Park to Chatfield Reservoir. The Montane zone is classified as a Class I coldwater aquatic life. The Transitional zone begins immediately downstream from Chatfield Reservoir and extends to the confluence with Big Dry Creek, near Ft. Lupton, Colorado. This zone is divided into three classifications: 1) the upper portion from Chatfield Reservoir to Littleton is classified as a Class I coldwater aquatic life; 2) the middle portion through Denver is classified as Class I warm-water aquatic life; 3) and the lower portion, known as Segment 15, is classified as Class II warm-water aquatic life. The Plains zone extends from Ft. Lupton to the Nebraska border, and is classified as Class II aquatic life. Water quality in the South Platte River, particularly in the Transitional zone, has been severely affected by mining wastes, municipal wastewater, industrial discharges, agricultural return flows and stormwater runoff. However, in the last 20 years, efforts have been made to improve the water quality and habitat in the South Platte river. In turn this has contributed to an increase in the numbers and diversity of fish that reside within in the river. The purpose of this presentation is to compare the habitats, hydrology and water quality in the three ecological zones of the South Platte River, with the historical and current distribution of fishes in these zones.

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The Importance of Understanding the Ecology of Plains Stream Fishes to Future Conservation Efforts

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ABSTRACT

Recent interest in the status and future conservation of fishes of Colorado's eastern plains, including those in the South Platte River basin, points out the general lack of basic information on their distribution and ecology. We discuss three problems which demand further research. First, historic collections are lacking, and recent ones are not assembled in a coherent format, which makes it difficult to recommend appropriate management efforts to conserve these fishes and their habitats. Second, relatively little is known about the basic biology of some of the most important species. For example, recent work indicates that several small plains minnows (Cyprinidae) may migrate upstream substantial distances and spawn during flood flows. Their eggs are buoyant and drift downstream, suggesting that they may require relatively long distances of river to live and reproduce. Third, collections over a 10-year period at sites along the Cache la Poudre River suggest that fish assemblages are dynamic, with some species appearing and disappearing through time. This suggests that recolonization dynamics may be important to long-term conservation of plains stream fishes, so that preservation of fragmented sites may be inadequate to preserve certain species.

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Assessment of Long-term Bird Population Trends and Changes in Bird Community Composition in the South Platte Basin of Colorado.

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ABSTRACT

The South Platte basin's avifauna is a critical indicator of the health of the ecosystems which comprise the basin. Birds in general, as extremely visible and ubiquitous vertebrates, are an excellent candidate group for ecosystem monitoring. In order to acquire a reliable knowledge of ecological structure and dynamics, however, it is necessary to have information which covers both a large area and a long time period. Very few long-term monitoring studies of western bird populations exist. One of the longest, the USFWS Breeding Bird Survey (BBS), is of some use for monitoring bird populations in the west, but suffers from biases (such as a bias against sampling of riparian areas) and lack of corroboration of trends by more local data, which can provide more fine-grained population information. One source of local data which is available is the field notes of amateur and professional ornithologists, which have been used successfully in the East (Hill and Hagan, Wilson Bull., 103(2):pp. 165-182) to supplement and test reported BBS trends. Similar population data from trips to the South Platte basin in northeastern Colorado has allowed testing of BBS trends, as well as adding information about species which are not sampled by the BBS. This data allows the determination of both population trends and changes in species composition over time throughout the high plains South Platte basin. The data available are 534 trip lists spread over 24 years with frequency of detection of each species, effort variables (miles by car, miles by foot, hours in the field), and weather information (cloud conditions, precipitation, wind, temperature). Analysis of these data indicate that while overall species richness in the South Platte basin has remained relatively unchanged, many changes in species composition have occurred. This includes the spread of many eastern species along the river's riparian corridor, a good instance of which is the Common Grackle (*Quiscalus quiscula*), which has experienced an increase over the entire basin within Colorado of approximately 61.61% in the last 24 years. These data have corroborated BBS trends which indicate other changes in Colorado's avifauna, such as a 1,002% increase in Brown¬headed Cowbirds (*Molothrus ater*) over the same period. Interestingly, these data also conflict significantly with BBS data in some cases. For instance, the BBS reports a statistically significant increase of 4.0% per annum for the Mallard (*Anas platyrhynchos*), while the South Platte data indicate a significant -11.41% per annum trend. This indicates that the using BBS data to make decisions about management at the local level must be done with caution. Finally, the South Platte data also document trends for species completely undetected by the BBS in Colorado. A prime example is the rise of the Cattle Egret (*Bubulcus ibis*), which increased from the first sighting of one individual in 1974 to an average sighting of 50 in 1991. All of these facts indicate that standardized, well-documented local data gathering is vital to monitoring

changes in avian populations. This effort should be continued into the future in order to detect changes in the South Platte ecosystem which might call for remediation, and to continue to provide a useful comparison to regional sources of data.

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Beyond Biodiversity: Towards a Third Generation of Tools for Ecological Assessement

Robert C. Peterson Jr. and Robert C. Averett

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ABSTRACT

The increasing need for simple and efficient tools for the assessment of water quality in running waters has gone through two major evolutions; a third is just now starting. First, there was the development of chemical criteria for water quality, which has evolved from simple parameters such as dissolved oxygen to detailed analysis of organic toxicants. This was followed by and then evolved with biological assessment, which resulted in lists of indicator species and methods to determine the community structure and function. Now there is a third generation of tools to assess running-water quality based on fluvial geomorphology and the physical structure of the stream channel and its riparian zone.

One of the third generation indices of the physical condition of running waters is the Riparian, Channel and Environmental Inventory (RCE) [Petersen Jr., R. C. 1992. The RCE: A Riparian, Channel, and Environmental Inventory for small streams in the agricultural landscape. Freshwater Biology 27:295-314]. It consists of 16 characteristics that define the structure of the landscape, riparian zone, stream channel, and the biological condition of the stream. The inventory is based on the premise that in landscapes where non-point source pollution and agricultural land use dominate, the environmental condition of small streams (< third order) can be assessed by an appraisal of the physical condition of the riparian zone and stream channel. It is assumed that disturbance of this physical structure is a major cause for reduction of running-water biodiversity. This assumption is supported by a case study using sites on 15 Italian streams in which the RCE was found to be positively correlated to the benthic macroinvertebrate community as measured by the Extended Biotic Index ($r = 0.793$, $P<0.001$) and the Shannon diversity index ($r=0.727$; $P<0.001$).

The RCE is designed to quickly evaluate a large number of streams in a short period of time. It generates a numerical score that can be used to compare the physical and biological condition between different streams within a region. The numerical score is divided into five classes to facilitate use in stream-monitoring programs and to allow comparison with other indices.

The RCE is recommended as an addition to, but not replacement for, other widely-used techniques. While the plethora of redundant biological indices may be thought of as being tedious, the fact that "nothing works all the time" leads to the counter-point that many tools are needed to form an arsenal of techniques for water-quality assessment.

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Effects of Stream Habitat Characteristics on Biological Communities in the South Platte River Basin.

Janet S. Heiny and Cathy M. Tate

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ABSTRACT

The types and abundance of organisms found in a stream reach are a function of the water quality and physical habitat within the reach. Our objective was to examine the relation among physical, chemical, and biological characteristics of stream reaches in the South Platte River Basin and the natural and anthropogenic factors affecting this relation. This study is a part of the U.S. Geological Survey's National Water Quality Assessment (NAWQA) program.

As a first step in this assessment, a synoptic survey of 23 stream reaches was conducted within the South Platte River Basin. Qualitative habitat measurements were made of riparian vegetation, bank stability and composition, presence and number of floodplain terraces, geomorphic channel units, and substrate composition. Also, we made quantitative habitat measurements of width, depth, discharge, bedform and substrate distribution, bank height, and bank angle using transects across the channel.

The relative abundance of algae and macrophytes were recorded along the transects. A qualitative assessment of invertebrates was made to select the sites for quantitative sampling. Invertebrates were collected quantitatively at the most "faunistically rich" substrate.

Dissolved oxygen, pH, temperature, and specific conductance were measured in situ. Water samples also were collected and analyzed for nitrogen and phosphorus.

We found a positive relation between physical, chemical and biological characteristics. However, chemical characteristics exhibited the least effect on invertebrate communities. Those reaches with greater physical diversity showed greater numbers of different types of biota.

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Pilot Project for Water Quality Biocriteria Development in the Lower South Platte River Basin, Western High Plains Ecoregion.

Wayne Roth-Nelson and Emily Weller

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ABSTRACT

U.S. EPA Regions VII and VIII are developing a pilot project on water quality biocriteria that will lead to a selection of biological metrics adapted to wadeable streams and rivers in the Western High Plains Ecoregion. The objectives of the current pilot project are to initiate biocriteria development by:

(1) The selection of several relatively unimpacted reference sites within candidate reference reaches and associated watersheds in the drainage basin of the Lower South Platte River in Colorado;

(2) The selection of an array of biological (and limited physico-chemical) water quality metrics for evaluating the biological communities and habitats and the ecological integrity of impacted sites as compared to the reference sites; and

(3) The development of scoring criteria for the selected metrics that will enable a subsequent recommendation of stream reach condition categories for the ecoregion (or subregion) that are based on comparability with the reference sites.

The pilot project involves a review and evaluation of exist-ing data and the solicitation of academic or research expertise. It is necessary to define criteria for selection of reference sites. Biological metrics will be placed in context with the macroinvertebrate ICI metrics and fish IBI metrics already pro-posed by the Nebraska Department of Environmental Control, par-ticularly as they pertain to the Western High Plains Ecoregion.

Beyond the pilot project, the ultimate goal is to develop potential stream biocriteria metrics for the entire Western High Plains Ecoregion that are suitable for technology transfer to the States of Colorado, Wyoming, and Nebraska.

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Key Climatic Characteristics of the South Platte River Basin in Colorado

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ABSTRACT

Climate is a primary control for natural ecological processes. Climate also helps determine some of the local requirements and costs for human adaptation.

Several key characteristics of the climate of the South Platte River Basin will be described to provide useful background information to other disciplines. Changes of precipitation and temperature with elevation will be shown. Seasonal distributions of temperature, precipitation and snowpack accumulation will be presented. The subsequent runoff patterns and streamflow distributions will be discussed. The remarkable diversity and variability of climate conditions within the confines of the South Platte River Basin will be demonstrated.

Factors that control the cimate operate on spatial scales much larger than the area of the South Platte Basin. Still, several man-made climate changes are evident in observed climate records in the basin. Examples of trends toward warmer and less windy conditions in the Front Range cities will be shown. Changes in streamflow volumes and their seasonal distribution in the South Platte over the past century will be emphasized.

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How Much Rainfall? A New Approach

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ABSTRACT

In the past, rainfall amounts associated with storms in the South Platte Basin have been monitored on a more or less idividual basis and little effort has been made to coordinate water decisions based on real time rainfall on a regional basis. The only Colorado weather radar capable of viewing these storms in an areal mode has been successful in determining areas where heavy storms are occurring, but has been singularly deficient in estimating how much rain was reaching the ground from any one storm or group of storms. This is no longer the case. In the future, Doppler Radar technology will allow various agencies not only to pinpoint areas where heavy rain is occurring, but also to furnish reliable estimates of actual rainfall occurring over a fairly wide area. This will enable water officials to make decisions concerning dam releases, stream diversions, etc., with a degree of certainty that will enable agencies to carry out their tasks in a more timely manner while at the same time reducing the problems associated with lack of action due to lack of data and of overreacting due to the "shotgun" syndrome.

This technology has been in use at the National Weather Service office in Denver for several years, undergoing development and testing. It has become an indispensable tool in National Weather Service operations in Colorado. At some point in the future, probably the near future, other agencies, including water agencies, will no doubt acquire this technology and adapt it to meet their own needs in obtaining real time rainfall information for various purposes. The possibilities of this technology are illustrated with an example of a heavy rain event near Greeley in July of 1989.

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Water Right Prices in Northeast Colorado: Changes, Trends, and Influences

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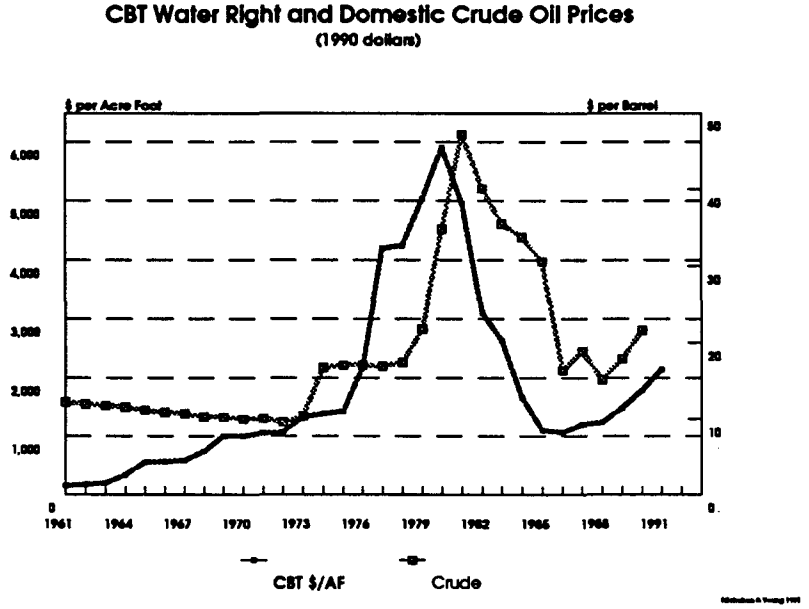
ABSTRACT

Water right transfers are proposed as a means to improve water use efficiency through reallocation to higher valued uses and as a method for improved river management in the western water arena. Establishing water right systems and transferring rights through markets is also gaining interest in other areas of the country that face difficulties with water allocation and shortages. Critical to this transfer process is knowledge about the current and expected prices of water rights.

Northeast Colorado supports one of the most well-established water rights markets in the world. Water imported from the Colorado River, across the continental divide to the Big Thompson River (CBT), is among the most actively marketed and traded in this area. The core of this market is the sale and transfer of water rights from one user to another. Prices for CBT water rights have changed significantly over the past thirty years. To what can these changes be attributed?

This paper examines the changes and trends in CBT water right prices over a thirty-year period in both nominal and real terms. Many factors such as agricultural land prices, population growth, energy development cycles, the development of supplemental water supplies and the governments macroeconomic policies have combined to influence water right prices. CBT water right prices provide an excellent opportunity to assess long-term trends in water values and markets.



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Water Quality Modelling of the South Platte below Denver: Opportunities for Improved Understanding of Ecological Processes

James F. Saunders, III and William M. Lewis, Jr.

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ABSTRACT

The South Platte River is subject to many uses, including domestic water supply, agriculture, and recreation. At the same time, it must serve as habitat for aquatic organisms. Regulatory agencies are responsible for ensuring that designated uses are protected. Governmental regulation of water quality has become relatively complicated, especially for nonconservative chemical contituents. As a consequence of the increased regulatory complexity, computer models have become increasingly important in regulatory decisions. Complex models can require a large data base; the accuracy of site-specific modelling depends heavily on an extensive data gathering effort. A good model can serve as a stimulus for an improved understanding of ecological processes, as well as a tool for planning and regulation.

Sewage from Denver and other municipalities has been discharged historically to the South Platte. As recently as the 1960s, water quality in the South Platte below Denver was severely degraded. Major steps have been taken in the last 25 years that have greatly improved water quality. However, there remains concern that aquatic organisms are not adequately protected. Of particular concern are the concentrations of dissolved oxygen and unionized ammonia. Debate has centered on the steps necessary to further improve water quality. Because treatment options like nitrification are very costly, alternatives should be investigated carefully. This debate has provided impetus for development of a site-specific water quality model.

Previous modelling efforts have been hampered by a lack of data suitable for model calibration. Extensive data collection efforts by the Metro Wastewater Reclamation District (MWRD) have produced a data record that will support model development. In particular, the District has invested heavily in the characterization of diel variation in major chemical constituents. Diel data sets have been essential for estimating rates of the major biological processes.

Modelling has yielded important new insights regarding the rela-tive importance of the key biological processes influencing dissolved oxygen and total ammonia. For example, nitrification was long thought to occur at rates that would rapidly deplete oxygen in the South Platte. Instead, analysis shows that nitrification proceeds at a relatively low rate and that sediment oxygen demand is most likely responsible for the depletion of dissolved oxygen. Revelations about the relative importance of key biological processes have considerable impact on the selection of wastewater treatment options intended to

improve water quality in the Platte. The modelling work has also pro-vided focus for future data gathering efforts. Sediment oxygen demand was estimated by residual in the current study, but the unanticipated importance of this process underscores the need for direct measurement. In addition, the importance of seepage chemistry in a gaining stream was not appreciated previously and merits further attention.

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Effect of Ground-Water Discharge on Dissolved-Oxygen Concentrations in the South Platte River at Low Flow

Peter B. McMahon, Kevin F. Dennehy, and Ken Lull

U.S. Geological Survey, NAWQA, U.S. Geological Survey

ABSTRACT

Ground-water discharge is an important source of water to the South Platte River during periods of low flow. For example, surface-water discharge measurements taken in August, 1992 showed that there was a 20 percent increase in the volume of streamflow between Brighton and Ft. Lupton as a result of ground-water discharge. The ground-water discharge rate in this reach was 15 cubic feet per second per mile. Although concentrations of dissolved oxygen range from about 2.0 to 6.0 mg/L in ground water adjacent to the river, concentrations are < 0.2 mg/L in ground water immediately underlying the river. These data show that streambed sediments are a sink for dissolved oxygen transported by ground water, and imply that ground-water discharge dilutes dissolved-oxygen concentrations in the river. As an example, if the concentration of dissolved oxygen in anaerobic ground water could reduce the surface-water dissolved-oxygen concentration at Ft. Lupton to 4.8 mg/L, a concentration that is less than the current regulatory limit of 5.0 mg/l. Large inputs of anaerobic ground water to the river near Ft. Lupton are consistent with observed low concentrations of dissolved oxygen (< 5.0 mg/L) in surface water in this area. These results demonstrate the importance of accounting for ground-water discharge in water-quality studies of the South Platte River.

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Directions in Water Resource Management on the South Platte: A Municipal Perspective

Douglas Kemper

Manager of Water Resources, City of Aurora

ABSTRACT

Since man first settled the South Platte Basin, he has placed a high value on use of the river and its tributaries for the needs of society. The hydrologic regime of the river has been modified through a variety of water management activities: diversions, return flows and releases from storage. The main objective of water management is to ensure an adequate supply of water. In the case of municipal water users, water treatment plants must always have enough raw water to meet demand. Municipal water management decisions reflect this directive. It is not likely to change in the near future.

Society's values are evolving toward a more complex view of our relationship with the environment. This view has yet to fully crystallized in the South Platte Basin. It may never be a static concept, but will continue to progress as our understanding of the river improves.

Defining of the ecological integrity of the South Platte Basin will be influenced by social values. However, arriving at a definition becomes a difficult process because nature itself is dynamic as is human society. Further, our knowledge of the river is limited because we have been present in this basin for a relatively short time and information is incomplete. Decision-makers may be frustrated by the lack of data for decades to come.

Water management, like all other areas of management, essentially involves two activities: deciding what to do and doing it. Much of the focus in the coming years will be on how we make and implement our decisions. Aurora has recently modified our approach to water supply development that we feel is more compatible with current attitudes of our citizens. Water users are actively developing tools to improve decision-making known as Advanced Decision Support Systems. These tools will also improve our communications - a must for efficiently implementing our decisions. Decisions that continue to reflect the values of our society.

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Issues of the Urban River Interface

Mark Tabor

National Park Service, Urban Design Forum Member

ABSTRACT

The Urban Design Forum (UDF) is a non-profit organization of planners, designers, and private citizens that are concerned with the issues of urban design in the Denver metropolitan area. Within UDF, a subcommittee has been formed, called the Urban Ecology Subcommittee, to explore the relationships between urban development and a healthy, functioning and sustainable local ecology. This inquiry is focused on the role of natural resources, their use, abuse, protection and enhancement within our 'built' environment.

The premise of this organization is that human systems in general and cities in particular, must develop a harmonious relationship with the natural environment to remain health and viable over time. Given that one of the most important and limited natural resources in the Rocky Mountain region is water is seems logical that we begin our inquiry of urban ecology with the role that surface water plays in our urban environment. Historically, the South Platte River has given form and orientation to our urban landscape.

The Urban Design Forum seeks to be a catalyst for discussion of the future of urbanized sections of the South Platte River. We feel that all the diversified interests of our metropolitan areas as well as the downstream neighbors in agriculture and water supply must be part of this discourse as well.

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Other
South Platte River Basin
Research

Channel Improvements Enhance Segment 15 Dissolved Oxygen

Richard Thornton, Camp Dresser & McKee Inc.

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Robert Neal, Metro Wastewater Reclamation District

ABSTRACT

Sediment oxygen demand (SOD) is suspected to be the primary cause of the depressed dissolved oxygen (DO) levels in Segment 15 of the South Platte River upstream of the 88th Avenue drop structure. Sediments trapped in this pooled area consist primarily of organic materials discharged with the Metro Wastewater Reclamation District's 185 mgd Central Plant effluent. These nutrients have created a rich food source for decomposition (respiration) by aquatic bacteria causing DO levels to drop below the 4.5 mg/l standard. The compliance schedule issued with the Metro District's new NPDES permit stipulates that channel improvement alternatives be evaluated to improve DO levels at 88th Avenue as soon as possible.

Concurrent with scientific studies to field measure SOD and assess aquatic habitats and wetlands, modifications to the 88th Avenue drop structure and stream channel are being considered to enhance reaeration. Alternative drop structure configurations and locations are being investigated through the use of flume testing at CSU's hydraulics laboratory. A physical model constructed at 1:25 scale will simulate erosion/sediment patterns, morphologic conditions, and hydraulic characteristics. In addition, the model will provide a means for assessing recreational safety concerns. A geomorphology study of reference reaches which exhibit good reaeration will provide additional design criteria for channel improvements.

An advisory panel consisting of representatives of regulatory agencies, affected municipalities and aquatic habitat and wetlands experts will assist the project team in developing a channel improvement plan that is compatible with ecological and institutional interests.

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Evaluation of Oxygen and Ammonia Levels in Big Dry Creek

Cynthia L. Paulson, Brown and Caldwell Consultants

Kipp Scott, City of Northglenn

ABSTRACT

The City of Northglenn recently undertook a modeling effort on Big Dry Creek to evaluate oxygen and un-ionized ammonia levels in the creek. The objectives of the modeling were primarily to evaluate impacts of dischargers on instream water quality, support wastewater planning and permit negotiations, and determine areas where data are lacking for future monitoring efforts.

Big Dry Creek was modeled from about 3 miles below Standley Reservoir downstream to its confluence with the South Platte River, for a total distance of about 19 miles. Three cities discharge wastewater effluent into the creek: Broomfield, Westminster, and Northglenn. The model addressed existing and future impacts of each of these dischargers on the creek. Instream water quality data collected at five locations on a monthly basis by the City of Northglenn were used to calibrate and verify the Region VIII EPA model STREAMDO IV. One diel sampling event was performed to provide a preliminary evaluation of 24-hour variations in instream water quality. A one-day field survey of the creek was also performed to provide a framework for the modeling effort.

Prior to the modeling, preliminary evaluations of water quality data showed that the critical period for oxygen and un-ionized ammonia levels in Big Dry Creek is in late summer/fall, due to low instream flows and high temperatures. As a result, the modeling focused on the low-flow high-temperature season. Constants and reaction coefficients used in the model were within the same range as values applied to Segment 14 and 15 of the South Platte River in other water quality studies.

A few of the more significant results from the model include the following:

·flows in Big Dry Creek during the summer low-flow season are highly variable and are heavily affected by irrigation diversions

·degradation of biochemical oxygen demand and ammonia loads occur relatively rapidly, so that the impact of each discharger on the creek is mostly dissipated before the next discharge enters the creek

As a result of the modeling effort, a number of areas were identified where additional data could greatly improve the ability of the model to accurately predict oxygen and un-ionized ammonia levels in the creek, including: diel sampling, chlorophyl a, flow/velocity, pH, and

sediment oxygen demand. The Cities of Northglenn, Westminster, and Broomfield have recently joined in their efforts to monitor water quality in the creek, and are beginning to incorporate some of these additional data collection needs into their joint program.

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Mutual Irrigation Company Monitoring of Main Canal Nitrogen Levels

John Wilkins-Wells

Department of Sociology, Colorado State University

ABSTRACT

The paper presents the results of research conducted during the irrigation seasons of 1991 and 1992 in the Cache La Poudre River Basin of northeastern Colorado. The study is funded by the Colorado Water Resources Research Institute, and is directed by Dr. John Wilkins-Wells, Department of Sociology, Colorado State University, with assistance from Dr. Ramchand Oad and Gary Sands of the Department of Agricultural Engineering, CSU.

The paper discusses the results of canal water tests, in-depth interviews and a questionnaire administered under the sponsorship of a local irrigation company to determine the feasibility of such a company to routinely monitor and report to shareholders the nitrogen levels in the company's main canal. The monitoring of nitrogen levels would provide a data base to be reported regularly to company shareholders when they called in for water orders. The questionnaire assesses the degree to which such information could be used by shareholders to adjust their sidedressing applications to take advantage of available nitrogen in canal water, or to alert shareholders to potential risks from nitrates to such crops as brew barley and sugar beets during critical growth stages. The in-depth interviews with company management staff and board members provides information on company management of their river decrees, and three company storage reservoirs; all of which receive return flows from other irrigated areas and local municipal water treatment plants.

The research was designed to assess the potential of such companies to initiate proactive water quality management programs that would address practical needs of shareholder-growers, while at the same time addressing overall water quality issues in the local river basin. Reuse of nitrogen as a supplement to sidedressing applications could potentially reduce the total level of fertilizer application in the company service area, and reduce the level of nitrogen in company return flows back into the river. The paper concludes with an assessment of the potential of such companies to actively address water quality issues in their service areas, thereby providing an immediate and replicable local organizational means of addressing this important environmental issue on a large scale.

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Distribution of the Subterranean Amphipod *Stygobromus* in Central Colorado Streams, With Notes on the Interstitial Community

Steven P. Canton, Don J. Conklin, Jr., and James W. Chadwick

Chadwick & Associates, Inc.

When compared to surface dwelling organisms, the interstitial fauna of Colorado streams is poorly known. Recent studies by Ward and Pennak at one site in the South Platte River have increased our knowledge of these communities, especially in terms of the species composition. However, the general distribution of these organisms in the South Platte basin is still not well known.

The present study was initiated in February 1988 in order to determine the distribution of interstitial communities in the upper South Platte River basin. Initial collections of *Stygobromus* in the South Platte River, specifically *Stygobromus pennaki* and *S. coloradensis*, were obtained from stream gravels resulting from the decay of Pikes Peak granite, a fine-to-coarse grain crystalline rock that weathers to a mixture of coarse sands and gravels. The present study concentrated on streams in the South Platte basin of central Colorado with substrate derived in large part from this Pikes Peak granite, with a few sites outside of the range of influence of this material. A total of 30 sites on 22 streams were sampled from 3 March to 28 April, 1988, with samples taken from both the hyporheic and shore zones.

The sampling efforts resulted in the collection of *Stygobromus* spp. from over 50% of the sampling sites. The 16 new distributional locations greatly increase the known range of the genus in Colorado. Notably, some form of interstitial community was found at all 30 sampling sites. This community was comprised of many of the same fauna as those described by Pennak and Ward from their single site on the South Platte River, including copepods, bathynellids, archiannelid worms and mites. Other groups not previously collected included cladocerans and tardigrades. This study strongly suggests that interstitial communities are widespread in Colorado streams.

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Defining Ecological and Sociological Integrity for the South Platte River Basin

October 27-28, 1992, University Park Holiday Inn, Fort Collins, Colorado.

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