South Platte River Resource Management: Finding a Balance

Conference Proceedings

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Preface

1990 was a watershed year for the South Platte River Basin. The decision to not build Two Forks Reservoir has likely signalled an end to the era of building large reservoir storage for the basin. Whatever the reasons for the decision, whether it be political or environmental, the position has been taken. Management of water resources must come from other methods rather than just permanent storage structures. If any form of permanent storage is to be built, it will probably come after extensive development of other sources. Some see it as only a last resort.

On another note, 1990 was also a year when water users of the South Platte began a new vision of cooperation. The year saw the first conference on the technical management of South Platte Basin water resources. This conference, titled *South Platte River Resource Management: Finding a Balance*, was initiated out of a growing need to better understand the resources of the basin, especially those related to water resources. As the title suggests, a balance needs to be found. Water users with different goals and objectives must be brought together to achieve understanding and cooperation. And with the multi-disciplinary conference which was held in Fort Collins in November, this occurred. While only the beginning of dialogue among different interest groups, the scientific basis and management orientation of the conference was a balance-finding exercise for all of the attendees.

This proceedings contains the abstracts of the presentations and the keynote speeches of the conference. As a reference, it brings together important research on the South Platte Basin and provides a multi-disciplinary approach to water management. For further information on any specific presentation, the reader is invited to contact the author given at the end of each abstract.

R. Craig Woodring, Editor
Colorado Water Resources Research Institute

Keynote Speakers

Water management on the South Platte River in Nebraska.

John VanDerWalker

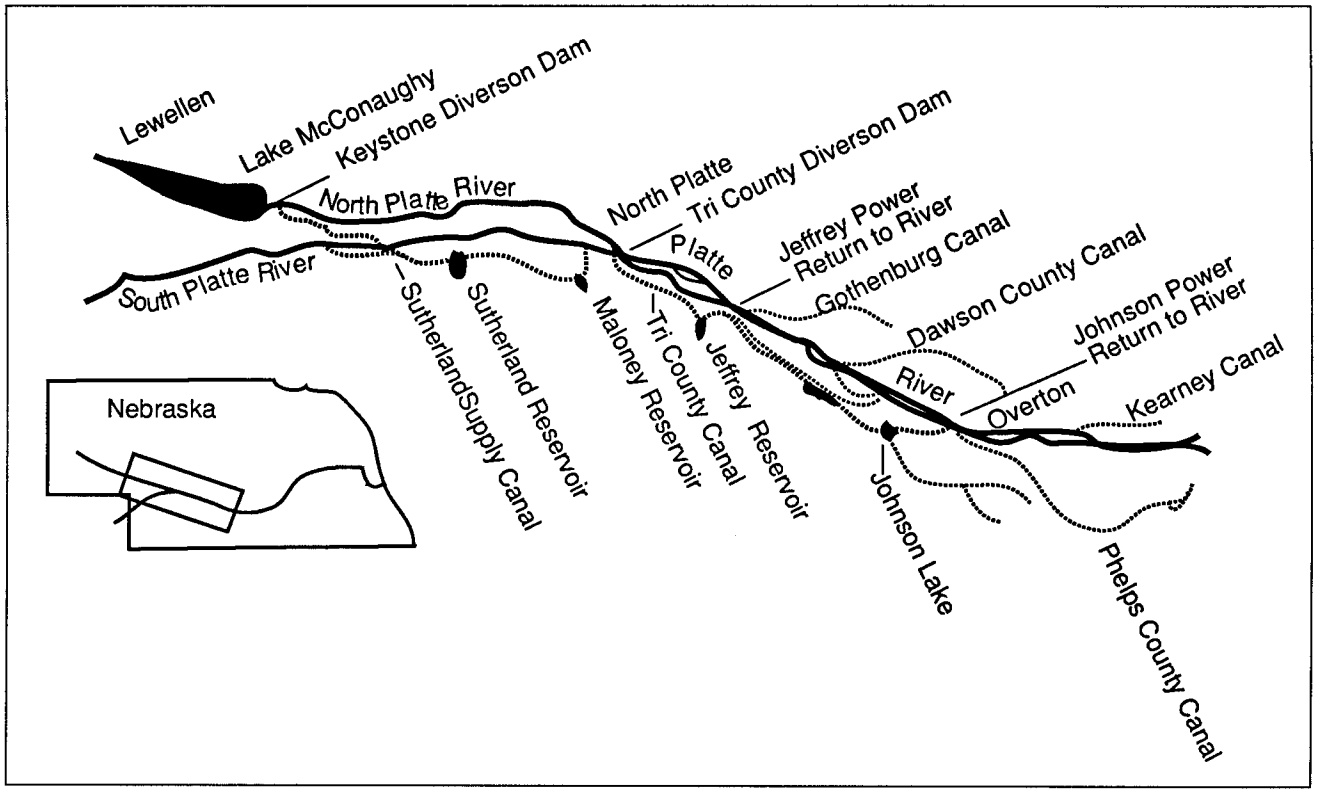
Executive Director, Platte River Whooping Crane Habitat Maintenance Trust

I'm glad to be here today and hope to stimulate a little conversation and controversy. I'm glad that I have a podium to hide behind in case some of you throw something at me. I guess I'd be partly disappointed if you didn't. I think that we need to have people stirred up. There's a broad cross section of value systems represented here and I don't think we're having the kind of rigorous debate we should, so I'm going to try to start it. I have been asked to talk about the Platte River in Nebraska and the re-licensing of Lake McConaughy.

I'd like to quickly tell you how the Platte River is managed is Nebraska and then talk about finding a balance in resource use. When I get into the middle of my talk, perhaps some of the things that I'm going to say should be applied the South Platte River as well. On the overhead (reference attached), you can see Lake McConaughy and Keystone Diversion Dam. Those are the segments which are being relicensed. Kingsley Dam stores about 1.7 million acre feet of water. Its operation determines the flow regime that occurs in the Platte River from Overton, Nebraska downstream.

To give you a quick view of how the project is operated, there is a winter operation and summer operation; depending on the time of year, one half the river is turned off in one location or the other. The Platte River summer flow at Grand Island, which is the downstream end, was as low as 29 cfs in 1989 and 1990. It is the upper end of the Big Bend reach of the Platte River, and that which we are most concerned about and are trying to restore. Essentially, the releases from Lake McConaughy may total close to 5,000 cfs during the irrigation season. However, the water that is released is diverted for irrigation use and very little of it stays in the river. The flows are often well below 200 cfs at the Overton gauge. A great deal of water is released

The Platte River System of Central Nebraska



from McConaughy in the summertime but it is diverted into canals between the Keystone Dam and Kearney Canal Bridge. There is only a small amount of water that gets by Overton to the Kearney Canal. Past the Kearney Canal there is very little water available in the river.

The other thing you should understand is how well water deliveries can be controlled. Approximately five thousand cfs is released from McConaughy in July. It's about a nine day travel time from there to Overton. Once released, water is diverted off the river with very little getting by Overton. From the Tri-County diversion at North Platte, Nebraska there's about 2,000 cfs of flow that's diverted into the Tri-County Canal that goes to Johnson Lake and Phelps County Canal. There is also a considerable amount of water delivered down the Platte River from the Tri-County diversion dam to the Gothenburg Canal and Dawson County Canal. This constitutes a lot of the flow in the Platte from the Keystone Dam to Overton in the summertime with very little flow downstream from Overton in the summer.

During the summer, flows at Grand Island vary. When the flow drops below 400 cfs, there is often an extreme rise in water temperatures and frequent fish die-offs which may also occur at flows to 800 cfs. Flows may vary from zero to 7,000 cfs in as few as 10 days.

Hydrographs from the Tri-County Canal diversion, near North Platte, Nebraska, indicate winter flow is diverted from the river into the Tri-County Canal. Water then flows to Jeffrey Reservoir, through the power plant before returning to the river. Therefore, in the winter there is practically no flow in the Platte below the Tri-County diversion. The hydrograph from the Brady Gauge, about 15 miles below the Tri-County diversion, indicates that flow into the river through the Fremont Slough comes from ground water. It is not water discharged from the Tri-County dam. Essentially, the project is designed to turn off the river from Keystone Dam to Overton in the winter and deplete the river from Overton downstream in the summer.

The critical question is "How do we find a balance between consumptive use of water and resource management"? This has been a more-than-contentious battle. The Nebraska Public Power District (NPPD), Central Nebraska Public County Irrigation District (CNPCID) and their five legal firms have spent eight to nine million dollars on legal fees and consultant studies to assure the river remains unchanged. The Whooping Crane Trust has challenged current river water management. We've spent about $100,000 on legal fees and almost that much on resource evaluation.

The regulatory history of NPPD and CNPCID is complex. Licenses for their projects expired in 1987. They were supposed to have submitted renewal applications in 1984, but failed to meet the deadline. However, when their applications were submitted they were found to be deficient from the lack of environmental studies and the delay continued. The Whooping Crane Trust became suspicious the irrigation districts were planning to operate indefinitely on annual licenses and filed a court grievance to place certain conditions on their annual licenses. To make a long story short, the irrigations districts are required to provide instream flows from February 15 to May 10 each year as recommended by the US Fish and Wildlife Service, Nebraska Game & Parks, and Whooping Crane Trust. Sadly, no permanent resolution of issues has been achieved and the contest over responsible resource management continues.

I prefer not to talk about the South Platte River. I had some strong reactions to a few of the presentations I heard this morning and frankly, I think there's a lot of myth in what was presented. I would want to be much better prepared with access to facts and figures before a discussion of issues. However, I have a hard time understanding how a conversion of 20 cfs of irrigation project water to ground water recharge would enable later projects to come on-line and divert 160 cfs. I don't know how you could put 20 cfs of water in storage for a 160 cfs release.

It's clear, from my perspective, that finding a balance between consumptive use of water and reasonable resource protection requires more water in the Platte River. If we are going to achieve a balance in water use, it has to be in the river and accessible when needed. I don't know which bank robber said this, it may have been Clyde Barrow of Bonnie and Clyde fame, but when asked "why do you rob banks"? He responded, rather incredulously, "well, that's where the money is"! I think there is a very real parallel in the water business. If you're going to put water back into the river system, you have to go where its banked. We all know where that is. The irrigators and their power brokers have a lot of water in the bank. More importantly the have water in the form of storage that's not being used. They have water in the form of several

irrigation projects that waste water and could be recaptured by improving efficiency. They have a lot of water in unconditional water rights that haven't been developed.

Other people have subscribed to Clyde's idea. If you want water, go to where the water is in the bank. Colorado Springs, probably pulled of the biggest heist in recent history. They closed down irrigation in the Arkansas Valley by transferring water to lawns in Colorado Springs and, in the process, dried up most of the Arkansas River. That was a perfect example of "taking water out of the bank".

I think all of you are familiar with the kind of exchange that took place with the City of Thornton, where the City purchased irrigation water and leased it back to agriculture until city growth requires use of the water. I wouldn't call Thornton's transaction a heist. I'd call it a temporary loan. Their agreement makes it possible for, perhaps, the irrigators to stay in business. It was the best deal the irrigation company could make since it is not likely that anybody will steal the water with Thornton providing a defense. But, for some reason this transaction has made the bank holding company in northern Colorado real nervous. It's because it is a threat to their power. One thing you must understand is - when a bureaucracy is involved, their real concern is power, not water as in this case. We have seen examples of that in Denver, where power is much more important than common sense or the public interest.

Another bank that is being tapped for new water is undeveloped conditional water rights. Years ago, people filed for unconditional rights and have been speculating with public resources ever since. Most of those rights have absolutely no hope of ever being developed. But, since most of the applicants were motivated by greed rather than public service they will probably figure out a way to convert their water rights to cash. Ironically, they want to sell a public resource back to the public and expect the public to pay premium prices. Either that, or they will donate the water right and take a tax credit. I believe instream flow advocates have to learn and accept this behavior. After all, the treasury has been taxed and taxed excessively, for irrigation projects. The last one in Nebraska cost the public $6,000 per irrigated acre. After development, the land was worth only about 900 to 1,100 dollars per acre and it only cost us 6,000 dollars per acre to add water. So we shouldn't be too concerned about financing. If we are going to protect stream resources we must embrace the same philosophies and procedures that have governed the water development community. The point I'm trying to make for those concerned about natural resource and public values is - you must be aware of the power structure and what motivates it.

Currently, most people concerned about natural resources are focusing on biology, hydrology, and ecology. In a sense, you're all on a quest for truth and believe truth will prevail. This is not likely to achieve positive results. One fellow recently mentioned that he could not understand why people weren't using models currently available for multi-resource management. He missed the point. People do not want their assumptions known. They don't want people to know how they make decisions or why they make certain decisions. They are much more comfortable making a decision than explaining the decision. It's very difficult to sell the idea of an objective planning process to people who don't want their assumptions or values made explicit. We all use models. There's nothing new about using models. What is different about using a current model to predict multi-resource management alternatives is the need to explain your assumptions and allow people to examine those assumptions. Believe me, the water community that possess substantial resources do not want a thorough public examination. They are very uncomfortable with the public demand for responsible resource management.

I already mentioned the logic of a Nebraska water project where $6,000 was spent to irrigate one acre of land. The taxpayers had to pay for that. The guy selling the land gets all the profit from a public investment. He bought the dryland ground for $200 per acre and sold it as irrigated ground for $1,100 an acre and pockets all the profit. At the same time, he is growing corn on that land which the taxpayers also subsidize. In Nebraska last year, the subsidy to farmers was 500 million dollars. That's the result of excessive production and misuse of water.

The truth is important. I think you have to pursue the truth and make good sound, scientific judgements about how you are going to achieve what you want. You are not anywhere close to correct unless you know the truth. Yet, in reality, we all function on myth. We're only halfway home in the pursuit and use of truth in decision making. Eventually one has to enter the political arena and that's where decisions are properly made. This is a democracy and we make decisions based on the political process. What I find

is that too few biologists and instream flow advocates are part of the political process. Somehow they believe it is a tainted process and shouldn't be involved. Consequently, we are in a very sad situation where wildlife and instream flows are concerned. So I encourage you, as biologists, to be involved in the political process. Get on your local county commission and other boards. Be involved in partisan politics. Write your senator - push! Because that's where the decisions are being made. You shouldn't be reticent about getting there correctly. People that advocate more water diversion certainly are not hesitant. Remember that it is money that belongs to you just as much as to anyone else.

You also have to recognize that you, as a resource advocate, are going to be at a distinct disadvantage. Because right now, people who want to take water out of the river are using taxpayer's funds to support their special interests. Until you get equal representation, you're going to have a real uphill battle and its going to require you put some of your own money into the process. Until we gain political influence, we only have a very limited opportunity to find a balance in water allocation in the Platte River basin.

I'd like to close by telling you what the Whooping Crane Trust is proposing on the Platte River and what balance we're trying to seek. In order to maintain viable resource values, we suggest a minimum flow of 2,000 cfs in the spring and fall, 800 cfs in the summer, and 1,100 cfs in the winter at Grand Island. There is substantial data which would support this recommendation. Unfortunately, I don't have time to go into that. What I want you to understand is that water is available in the Platte basin to support these flow recommendations in an average year. It will only require a change in timing of the flow. Early spring and some winter flows normally in the river could, in part, be stored and released in July and August to fulfill flow requirements.

All of you know averages don't mean a lot and we're not going to achieve these recommendations all the time. We are not proposing an increase in water delivered to Lake McConaughy. We aren't trying to take water from anybody. The water we encourage for minimum flows is already available from hydropower production, facilities maintenance or uncontrolled flows. What we're trying to do is get Lake McConaughy re-regulated so it will store more water in the winter and release it in the summer. We have developed a storage and flow schedule that can accommodate our instream flow recommendations without affecting any existing irrigated acres. We recognize we may not be able to achieve our flow needs all the time but we can make a significant improvement in river conditions. Somewhere from 45% to 65% of the time we will be able to meet our flow needs.

We also recognize during high flows we will fulfill our minimum flow recommendations and during periods of low water availability we may not. We have proposed a series of triggers that, as water supply decreases, instream flow demand decreases. This is stepped down until we reach a lower limit of 400 cfs. When the reservoir drops below 900,000 acre feet, no instream flow releases will be required. It is our belief we could maintain good habitat conditions 50% of the time or more. We then can survive occasional drought conditions.

To further explain, the instream flows we have recommended will provide more protection to irrigators because reservoirs would be operated at higher levels more frequently and there will also be an increase in reservoir recreation, fisheries and other uses over base operating flow. Hydropower production may be reduced by 3 to 6 percent because instream flow deliveries to Grand Island in the summer would be an addition to current releases. The hydro units, located on irrigation canals, would be bypassed by the instream flows because, obviously, the flows are restricted to the river.

This is the balance we are trying to achieve. I believe we can maintain existing irrigated acres throughout the basin and increase water availability to other users by better management. That includes increasing water efficiency by on-farm users. Experiments in eastern Colorado have reduced on-farm water consumption by 40%, simply by applying moisture-block technology. There are places in Nebraska where 30% reductions or more in on-farm use have occurred from the installation of a simple valve that costs about $1,500.

There are a lot of opportunities for increasing the available water supply. Some of the more exciting are conjunctive use projects. We believe there are big opportunities for that in Colorado. We are facing a crucial situation. When we go the bank, are we going to rob someone like Colorado Springs did in the

Arkansas Valley or are we going to try and improve the situation in a way that will allow water users to maintain their resource productivity, lifestyle, and economy. Are we willing to take some of the fat out of the system so others can share in the bacon?

If I were to issue a warning, water is going to change hands. There's going to be a significant change in use and it may not be just for instream flows but for other things as well. Change is one thing you can be absolutely sure of. Water quality and instream flow issues are becoming more important every day. The people who have the water today, are going to have large control over how change occurs. It can occur in a way that is very damaging or it can be constructive. Serious thought must be given on how they will address that inevitable change. I have to say, in our particular case, the NPPD has said "we know we have to change - we know instream flow values are critical and must be protected and are willing to work toward those goals". They've said this in the newspapers, editorials, speeches and in seeking resolution to the issues. On the other hand, the CNPID says that no change is necessary-there's more wildlife now than we've ever had and we're not going to adjust.

We're locked in this struggle. We can sit down and mutually develop a solution or we can face each other in court and allow the legal system to determine the use of our water and determine the management of our resources. I'm certain if we go to court, we're going to have a less satisfactory resolution of issues than if we solve them ourselves. Thank you.

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South Platte water research — Key to solving problems.

Dr. Neil Grigg
Director, Colorado Water Resources Research Institute

It's clear that we're dealing with a subject where we should be blending disciplines. Better science and understanding of the river is going to be the key to resolving a lot of our conflicts. I want to explain what some of these conflicts are and why we need better understanding through research to make progress on them.

I want to introduce two people who have key roles in the South Platte and water management in Colorado. Here is Mr. Bill Farr. He has been a water statesman for a long time. He is a member of a pioneer family. His grandfather was here in 1876, beginning to farm on the South Platte. The other person is Marvin Jensen. Marvin has recently joined Colorado State from a long career with the Agricultural Research Service where he was national program director for water management. Now he directs the Colorado Institute for Irrigation Management.

Now why do we need better understanding of the river if we're going to make progress. My first point is the economic importance of the South Platte river basin. I think it should be clear to everybody how important this fickle South Platte River is to Colorado's economy, but it is hard to link economics and water very closely. The economists say that water resources are not a determinant of economic development; they are a necessary condition in many cases but they do not determine economic development. But in Colorado I think that the picture is more complex than that and that the linkage between our water resources and our economic development is stronger than most people realize. While I can't give you the numbers and the research conclusion to prove that, just a couple of facts about the S Platte illustrate it.

The South Platte basin supports something like 70% of Colorado's population. We have a water reuse ratio of about 3 to 1 in the basin. Now a lot of people will tell you that all we have to do to provide the water supply for Denver is to take the water out of agriculture. But how we going to do that. Are we going to change our reuse ratio to 4? I mean this is an awfully complicated question. There is about 1.2 to 1.3 million acres in irrigation in the South Platte. About 1.2 million acre feet of water which is generated in that basin and between 300,000 and 400,000 acre feet of imported water. But going beyond that, we've got two aquifer systems which need to be managed better. The deep aquifer system, which has estimates of storage ranging from 250 to 300 million acre feet, has anywhere from 40,000 to 100,000 acre feet per year of annual recharge. We don't understand that aquifer very well. We're still trying to do research to try to characterize it. And then we have a shallow aquifer which has about 25 million acre feet of storage and in a recent year, that is 1970, about 1.6 million acre feet pumped out of that aquifer. So we're really talking about big numbers here. The South Platte is a economically very important resource and needs the best management that it can get.

A lot of challenges face us in trying to manage the river better. I look at these challenges in the categories of different types of complexities.

The first complexity is the scientific complexity. The river is complex enough if you just look at the interaction between the surface water and the groundwater and you look at that reuse factor. But if we start bringing in the ecological aspects: the vegetation; wildlife and the fisheries that we've been talking about at this meeting, I think the total complexity becomes even more clear.

The next category of complexity is ecological and value complexity. We have a hard time talking to each other at meetings like this because we don't use the same language. If we got down to the different points of view about how each person thinks that the river and its resources should be used you would see a really wide divergence of values. There are some people in Colorado who hold the extreme environmental position and they would want to sacrifice all of the farming to restore natural values. There are other people in Colorado who would think that the natural values were not something deserving attention and they would

want to develop every last drop without regarding any instream flows. In the middle you have all of the variations of position. Those value challenges are probably the biggest ones that we confront today.

The next category of complexity is the legal complexity. We've heard a lot about wasting water to Nebraska here at this meeting. That's one of the illustrations of legal complexity. You put yourself on the other side of the state line and you look at it from Nebraska's point of view. Looking upstream rather than looking downstream and that's not water waste, that's water entitlement. With all the controversy over the whooping cranes in Nebraska, did we ever think realistically that we're going to be able to capture that last 300 to 350,000 acre feet on the South Platte. So the legal complexity is there, even without discussing the management complexity that revolves around the water court system.

The last category of complexity is political which has a lot of dimensions. The first dimension is the inter-regional dimension, and on the Platte River system there are a couple of ways to look at that. One is between Colorado and Nebraska and then another is to realize that a lot of the water that is in the Platte river system comes out the Colorado River system. So on an inter-regional basis you have politics on the South Platte ranging all the way from Los Angeles water supply to the whooping cranes on the Big Bend region in Nebraska. We have a lot of politics right here in Colorado, intra-basin politics. We settle these peacefully, I mean Thornton is represented right here at the same table where we have Fort Collins and Greeley represented. But there's a political conflict there that has to do with how we are going to accommodate ourselves within the basin. The federal-state issues that we hear so much about are another example of political complexity. What are the goals and the missions of the different federal agencies, whether its the Fish & Wildlife Service, EPA, or the Corps of Engineers. The difference in point of view of those agencies is the rightful claims of the federal government relative to the state government and our interests in Colorado. And finally in terms of political controversy and conflict, we have a lot of internal conflict. You can't conclude that all of the water management districts in all of the cities and all of the farming groups are willing to work together. So when you add up all of those categories of complexity and difficulties and conflicts, you see what a challenge we have.

Using research to deal with the value conflicts and the political conflicts is difficult. Those conflicts have to do with personalities and points of view and they're going to be really tough in the future. But the one thing that we can do through research is to provide more information that sheds the light of day on costs and benefits and will help us a lot in those conflicts.

To illustrate what we can do through research I'd like to underline two or three opportunities that we have in front of us. These are opportunities to do things better. And what we want to do better, in general, is to provide the water supply that is needed for cities and agriculture. That's our challenge, to do the best that we can for all of those categories. That doesn't mean one to the exclusion of the others but to do the best that we can for all. Well, these opportunities that we have revolve around water development and water management. Some people assume that the question of water development is finished in Colorado, that there is not going to be anymore water development. But we really don't know; what about the lower South Platte, the Narrows and the Harden site? I think that some of the environmental benefits over in Nebraska might be helped by looking at those storage opportunities. I think that we have gone beyond the court battle on that and it's time to look at those opportunities with new possibilities in mind.

It's the area of water management where we have the greatest opportunity to make advances through research. If you look at the opportunities that we have in front of us, they are really exciting and awesome, starting with conjunctive use and water banking, using that aquifer better. I don't have time to go through the details of the research that we have completed at the water research institute the last few years, but I will mention one. About ten years ago, we did a mathematical modeling study to try to learn how to prevent the "waste" of water into Nebraska-using that terminology again. We found that the use of the South Platte aquifer on a conjunctive basis was the way to influence that. You can do more through using that aquifer and conjunctive use then you could through all kinds of techniques such as lining ditches and agricultural water efficiency improvements. And the reason, of course, was because of that reuse factor.

Another opportunity that we have is to do a better job with exchanges. In particular, city-to-farm exchanges. There are a lot of obstacles to getting those adjudicated, getting the agreements in place, having those exchanges valid during drought years and maybe not valid during times of plenty. Whether that has

to go through the water court, or doesn't have to go through the water court, there are many obstacles in place but the opportunity is great.

In order to affect some of those, we need better models, data bases and decision-support systems. The last two presentations that we had, by Tim Gates and Chuck Haines, were really enlightening to show what can be done through those decision-support systems. In fact, I was just inventorying the projects that the Institute has financed for this year. We're only able to finance small projects because of the limited funding that we have. And I saw that six of the ten projects that we have for this year are aimed at subjects like that, data bases, decision-support systems and models.

The last opportunity which is the greatest is the one that I've been talking to Bill Farr about because he has such keen insight about regional water management and integration of water management. Most people who approach water management in Colorado and who don't work in water management, have no idea how complex it is. And of course, the further you get from Colorado, the simpler it seems. I was in Washington and was amazed to sit at a meeting and hear everybody just hold forth about how the easiest solution to the Two Forks problem was to just take that agricultural water that was being wasted so badly. I could hardly believe my ears. You know they had it all figured out but as soon as you get here to Colorado and you see how complex it is, politically complex, legally complex, scientifically complex and so on, then you see that it doesn't work out to be quite that simple. But the opportunity that we have by working together and doing a better job for regional water management is really awesome.

Now what's going to happen if we don't get our act together versus if we do get our act together? I was thinking about what's going to happen in Colorado, particularly on the South Platte, which is the most intensively used and developed river basin in the state. I could see three scenarios: the worst case, the status quo, where we are now and the best case if we could work together, use our research and make improvements. Under the worst case, which I would call the ultra-conflict case, there's going to be a lot of work for lawyers and engineers. There would be a lot of business for biologists and fisheries people testifying in court, arguing this and that, going on both sides. The trouble with all of that business is that it doesn't lead us anywhere, we're just spinning our wheels. Many service professions and consultants are making money but we're not becoming more productive. That money has to come out of the hides of producers. So if we have this ultra-conflict scenario, that's going to be the end result as I see it.

The status quo scenario is where we are right now. The best scenario is one that I would call the cooperative basin management scenario. We start working together, we try to find balanced approaches to providing a water supply and meeting ecological needs. We have better regional water management within regions and not only are we able to manage our water within regions such as inside of northern Colorado and inside of metro Denver, we're also able to share water between the regions. For example, if we can really get our act together in Northern Colorado, there may be ways to work together with the Denver metro area and we could have a total approach which is going to be in everybody's best interest. This is the scenario we're looking for. If we don't move toward that we're going to be either in the status quo or we are going to be in that complex scenario.

What research is needed for this? A lot of research is needed but I picked six topics as illustrations of what we need. Each of these six topics constitutes a major area of priority for CWRRI and CSU. They are also priorities for some of your agencies, and your agencies and organizations need to take part in a cooperative water research endeavor for the South Platte. After all, a lot of research is needed. We're talking about a resource in that river that's worth billions of dollars as an asset value.

The first category of research is better cooperation in a data base and models for decision support systems. You can see the possibilities in those presentations today, Chuck Haines, Tim Gates and John Labadie. By working together the water users, the State Engineer's Office, the universities, as Chuck painted the picture, we're going to make a lot of progress in that area. If we can sustain it. If we start it up and we stop it, we're not going to get where we need to go.

A second category is that there is a whole family of projects needed in groundwater recharge and conjunctive use. A third category is more research to find the ecological balance and the best way to use our wetlands. A fourth category is water quality. Jack Odor stated that they hadn't paid attention to water

quality in the beginning but now they are. It's my firm opinion that we better pay attention to water quality.

Another category of research is one which may not be done through the university. It has to do with better approaches to regional water management. We heard about two studies just this morning that are going to give us some real insight on that. The first one was the presentation on the management of the South Platte system. The second one is a study which is being coordinated through the Northern District. It has to do with coordinating the regional water infrastructure in northern Colorado. That was going to be reported out in the near future and I'm really looking forward to the results of both of those.

The last category of research needed as I see it is one that ties the economics together. I don't know if we have any economists here or not. We normally have some economists at a meeting like this. The Institute has supported several studies trying to relate economics and water development in the state. The conclusion of some of those studies has been that the return of the water which is put into farming and agriculture is very small related to the return on the water which is used for urban development. You could carry the argument all the way to the point that we should dry up all the agriculture and let all the water go to Denver. And then if we could solve our air pollution problem and our people pollution problem, well the state would be much better off. But I don't think that is the case. Then we have the recreational industry. The recreational industry doesn't amount to any great shakes as far as economics of the water which is needed. The tourist industry is a big one in terms of economics. But you can't show the direct linkage between the water which is provided there and the economic impact of it.

So we have these three great industries. Agriculture, recreation and urban development which has with it the industries. We need economic studies to show what the balance should be in providing water and how it should be provided. It would be nice to have all of these studies. We don't have the funds to get them going at the university right now. I figure that we would need about $500,000 to a million dollars per year to put into an adequate research program to really attack all of those topics. Fortunately, in some of our projects, as in one Chuck Haines reported, by getting some coalitions together we are able to generate a little more money and make some progress on some of those really essential areas. I'm hopeful for that approach in the future, provided all those water users keep coming forward with their share and the others come forward with their share, we'll be able to sustain that.

Any of these research projects should be collaborative in any case. They should be collaborative between the university, the scientists, agencies, water users and people who are involved in water policy. The need is for research to solve this problem in the South Platte. If nothing else, we all need to understand how complicated this is and how essential is getting that scientific understanding and the data bases improved. I want to extend my personal thanks to everyone who participated in the conference. I've been amazed at the levels of expertise in different subject matters that we have here. If the organizers of the conference could sustain this general approach, this conference could become a periodic event. We could begin to have different disciplines in here with the knowledge which is needed so that we could begin to integrate our understanding of this system. What we have at this conference is partial integration. We're covering water management pretty good, we're covering vegetation and ecology pretty good. But we haven't heard anything from the agricultural side, there's no water lawyers here, no economists have surfaced and probably a few others are missing. We might just be able to do a better job in the future. Thank you for your attention and enjoy the afternoon.

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Session I:

Hydrology of the South Platte River

The evolution of the South Platte River - From an intermittent and seasonal stream into a dependable resource.

Bart Woodward

Manager-Riverside Irrigation District; Vice-President- Colorado Water Congress; President - Groundwater Appropriators of the South Platte; and Board member - Water For Metro Denver.

ABSTRACT

When looking at the conflict surrounding management of South Platte River water, what is often missed is the history. How the river functioned before the arrival of the white settler is far different than it is now. According to historical records, more water goes down the river today than was seen historically.

Journals of John C. Fremont in 1842, as well as trapper and wagon train reports, document that the South Platte was a stream of high flows in the spring due to snow melt while so low in summer that it was considered nonexistent. Studies in the 1920s for the South Platte River Compact verify this.

Water development which started in the 1860s in the form of irrigation created return flows and wetlands along the river. Until the delay of return flows established a higher water table of deep percolation flowing back to the river, very little riparian vegetation was documented. The riverbed was barren of the cottonwoods which mark it today.

Today, the South Platte is what it is because of reservoir storage and 'land storage'. Flood flows and snow melt are captured and the high peak flows of spring are spread over the summer months. Water percolating below the root zone of irrigated crops returns to the hydrologic system and helps create wetlands and flows for downstream users.

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Water budget for the South Platte River.

Alan D. Berryman
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ABSTRACT

The saying that one man's waste is another man's water right has been proven true on the South Platte River. When looking at the water budget of the river today along with the historical pattern of development, it can be seen that return flows are a critical process in South Platte River hydrology.

Irrigation began in the 1860s along the river banks of the South Platte as early settlers began to produce food for miners and themselves. According to documents from the 1880s, canal systems were developed which carried river water away from the banks and increased the developed irrigated acreage to 43,700 acres. An 1896 Colorado Agricultural Experiment Station Report stated that those streams through or adjacent to irrigated areas had developed an increase in water supply proportional to the irrigated area while streams in dryland areas had not. After development, return flows from irrigated areas were putting water back in the river at times later than the typical early spring flood flows.

This pattern has been generally reflected in the decrees of water rights in the South Platte Basin. The first surface rights were developed from 1859 into the early 1860s starting primarily where the waters entered the plains on Boulder Creek, Saint Vrain Creek, and the Cache la Poudre River. These rights are some of the earliest in the South Platte. Next came water developments between Denver and Greeley which were decreed in the late 1860s and the 1870s. Water developments moved down the river to Nebraska with many surface decrees occurring in the Fort Morgan area in the 1880s and farther downstream towards Sterling and Julesburg in the 1890s. Today, 2.8 million acre-feet are diverted to irrigate about 1.8 million acres of land and serve a population of around 2 million people.

Following the direct flow development in the late 1800s, came reservoirs. According to an 1896 report of the State Engineer, reservoir construction was becoming a major activity in the basin. Today 780 reservoirs in the basin store several million acre feet of water, motst of which is diverted in the winter or during high runoff events.

Groundwater development was documented in 1913 with 79 wells being reported in Division 1. These wells, primarily pumped by gasoline or kerosene, were used to irrigate 8000 acres. Well development has continued with surges generally occuring in drought years such as in the 30s or 50s. Today it is estimateded that 12000 large capacity wells are diverting about 1.6 million acre feet per year in the basin.

Another component of the South Platte Water Balance is trans-mountain diversions that currently account for up to 400 thousand acre feet of water entering the basin each year. These diversions occur all along the divide, with the majority coming from the Upper Colorado River basin.

Today, most of the primary development of water resources has occurred and the main efforts are centered in managing changes within the basin as to how the system is operatedand as to where the water is used.

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Effects of urbanization on hydrology of the South Platte River.

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ABSTRACT

Over sixty percent of the South Platte River basin in the Denver metropolitan area is urbanized. This urbanization has affected the hydrology, channel morphology, and water quality of the South Platte River in this reach. The magnitude of impacts varies both in time and location along the river.

One of the more pronounced changes is the great increase in the magnitude of storm flow due to increased runoff from impervious land uses. A more subtle effect is the increase in baseflow in urban basins due to increased use of water for urban uses (e.g., car washing, lawn watering), much of which is water imported into the basin.

Changes in channel morphology include an increase in channel size to accommodate greater flows, and severe channel bottom degradation which has occurred as a result of past gravel mining in and adjacent to the river. High levels of suspended solids and associated pollutants occur during storm events; studies show that contaminants stored in sediments may be released and effect water quality during base flow periods.

The effects of urbanization on the South Platte River in the vicinity of Denver, in turn, impact important resources including: aquatic life, fish, recreational opportunities, and riparian habitat, and wetlands. These considerations must be addressed in resource management decisions for the South Platte River.

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Analysis of changes along the lower South Platte River.

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ABSTRACT

The water resources of the South Platte River have been developed to convert a portion of what was called the Great American Desert to a quite productive agriculturally-based society. As a result of this development, considerable amounts of water are stored and diverted out of the river. Offsetting to a degree the use of South Platte water is that on the order of 300,000 acre-feet of water is brought into the basin from the Western slope by means of trans-mountain diversions. Even with this import of water, streamflows have generally been reduced. Such changes in streamflow have been one of the primary causes for a change in the channel itself. Based on an analysis of maps from the 1800s on through to recent aerial photographs, significant portions of what used to be active channel in the plains region of the South Platte are now vegetated with cottonwood trees and other vegetation and the current active channel is now considerably narrower.

Being an alluvial river, the size, shape, and type of river that the South Platte was and has become is determined by the flow, the characteristics of the channel bed and bank material, sediment transport into and through the river, and the interaction between vegetation and the river. Currently the South Platte as well as other rivers in the Platte system are being studied by a number of groups who are either promoting additional development, promoting habitat issues, arguing against development, or who are attempting to maintain current operations of existing projects.

Several theories have been brought forth regarding the cause of changes to the channel as well as theories regarding what should or should not be done to maintain or improve it. Analysis has been conducted to determine, which, if any of the theories are correct. Results of the analysis has shown that in fact many of the theories are only partially valid at best, requiring a more comprehensive development of the cause and effect relationships of channel change. As part of this work, a computer model has been developed to relate channel change to the primary causative factors. This model has been successfully calibrated with historic data and has been used to predict the future of the river channel under various scenarios. By using such a model, proposed management alternatives can be tested to see if any might be worth pursuing in terms of channel maintenance.

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Decision-support system for conjunctive stream-aquifer management under prior appropriation.

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ABSTRACT

Colorado is faced with increasing pressures for satisfying expanding urban water requirements, while insuring that the important agricultural sector of Colorado can continue its vitality. Water conservation and improved water use efficiency are viewed as key factors in achieving these goals, and yet the consequences of these measures must be carefully assessed since they can have dramatic basin-wide impacts on other water users. In the South Platte River basin, cooperative exchange agreements, plans for augmentation and water rights transfers have greatly magnified the complexity of water planning and daily water administration. In spite of the complexity, comprehensive, computer-based decision support systems are not currently being employed by many of the important agencies and organizations in Colorado responsible for water planning, management and administration. Research has been initiated at Colorado State University on synthesis of a graphical-based decision support system (DSS) which is suitable for basin-wide analysis for long term planning, as well as daily administration. The primary public domain modeling tools with the greatest potential for incorporation into the proposed DSS are the SAMSON and MODSIM-CONSIM packages developed at Colorado State University. These packages were developed through grants administered by the Colorado Water Resources Research Institute, including funding support from the State of Colorado. Other models exist, but suffer from various deficiencies such as: inability to properly model the water rights structure, designed for a particular region, or privately owned and proprietary. The proposed DSS will attempt to build on the best features of these two packages. A *cafeteria*-style approach will allow selection of various modeling components to match the level of detail required in the study. The proposed DSS will be unique in its ability to directly incorporate the appropriation doctrine in Colorado water law, as well as include important stream-aquifer interactions for optimum utilization of surface and groundwater resources. The usefulness of the DSS will be demonstrated using a portion of the South Platte River basin as a case study.

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Session II:

Water Quality and Fisheries of the South Platte River

Overview of surface water quality of the South Platte River Basin.

Dennis Anderson

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ABSTRACT

The water quality of the streams in the South Platte Basin are generally of high quality in the higher elevations with gradual degradation as they flow on to the plains. This is reflected in the classifications and standards of these waters. Nearly all of the higher elevation streams, which for purposes of this talk are those above about 6,000 feet elevation, are classified for all uses (i.e., recreation, aquatic life, water supply and agriculture uses) with standards reflective of the most stringent criteria. They also are designated as high quality streams meaning they are automatically subject to antidegradation reviews.

As the streams flow onto the plains, more ambient standards or standards reflective of water quality which naturally exceeds the criteria to fully protect the classified uses come into play. Also, many of these streams go from an aquatic Class 1 to an aquatic Class 2 designation and in most cases for the intermittent streams only minimal standards are in place.

The reason for the lower water quality in the lower elevation streams is for the most part due to diversions and returns of the streams for irrigation and in many cases the effect of point and non-point sources of polution as the streams pass through urbanized areas. While the quality is lowered in these transition zones, most streams are by no means considered polluted. In nearly all cases, the water quality in these lower elevation streams meets the criteria for the uses in place.

The few streams that are considered severely polluted are nearly all high elevation streams impacted by heavy metals from mining activities. Examples of these are South Mosquito Creek and Geneva Creek in the Upper South Platte drainage, Woods Creek, North Fork Clear Creek and Clear Creek from Idaho Springs to Golden in the Clear Creek drainage, and Little James Creek in the Left Hand Creek drainage. The only streams considered severely polluted by constituents other than metals would be the lower reaches of the Big Thompson and Little Thompson Rivers which are impacted by point and non-point sources of fecal coliforms and Boulder Creek impacted by un-ionized ammonia from wastewater treatment plants.

One unusual characteristic of the quality of the Lower South Platte River that is not well known is that the average uranium concentrations are the highest of any basin in Colorado. Although not at a levels to be of concern to the public, they are much higher than the average levels found in nearly all the uranium mining districts of Colorado.

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Recovery of stressed aquatic communities — An incremental assessment approach to evaluation of water quality and non-water quality related factors.

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ABSTRACT

The Metro Wastewater Reclamation District (MWRD) operates a wastewater treatment plant that serves much of the Metropolitan Denver area. The District discharges approximately 150 MGD of secondary effluent into Segment 15 of the South Platte River. Segment 15 extends from the headgate of the Burlington Ditch in Denver, to the confluence with Big Dry Creek in Weld County.

Secondary treatment includes removal of suspended solids and biochemical oxygen demand (BOD). Historically, effluents were chlorinated, but not dechlorinated. Conventional secondary treatment does not remove ammonia. A portion of this ammonia (un- ionized), and residual chlorine are toxic to aquatic life in receiving streams. Effluents also contain "nutrients" such carbon compounds, phosphorus, and low levels of nitrate nitrogen which affect aquatic life.

Prior to the construction of the MWRD, the river was severely polluted with primary sewage effluent. After construction of the MWRD, water quality conditions in the river improved substantially, and some fish species began to return. However, the river was still considered only marginally suited for aquatic life. The current Class 2, warmwater aquatic life classification attests to this fact. The primary water quality problems that persisted until only recently were related to chlorine, ammonia nitrogen, depressed dissolved oxygen (DO), and high fecal coliform counts. Chlorine and un-ionized ammonia concentrations sometimes exceeded the chronic standards of 0.003 and 0.1 mg/L respectively, and DO often dropped below stream standards.

During the mid 1980's, the USEPA determined that water quality in Segment 15 was not protective of aquatic life. Subsequently, in 1987, the MWRD received new discharge permit requirements. They required complete removal of residual chlorine along with seasonal removal of ammonia nitrogen from the effluent. Dechlorination became operational in October, 1988, and partial ammonia removal will become operational in October, 1990. Dechlorination has eliminated chlorine toxicity and it is anticipated that partial nitrification will eliminate ammonia toxicity in the future.

To assess the success of these process upgrades, the District devised a plan to assess the incremental benefits of each phase in bringing about improvements in water quality and aquatic life in Segment 15. The study is being carried out in three phases. In Phase I (baseline studies), water quality, physical habitat, and the health of aquatic communities prior to dechlorination and nitrification were documented. Phase II studies essentially repeated the same data collection after start-up of the dechlorination facilities, but prior to start-up of the nitrification process. Phase III studies will collect the same type of information after the start-up of the nitrification facilities in the fall of 1990. Results from dechlorination improvements demonstrate our success in improving Segment 15 water quality. Results on the recovery of macroinvertebrates and fish species are being presented in companion papers.

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Incremental assessment of the benthic macroinvertebrate community as it is impacted by sewage effluent in segment 15 of the South Platte River.

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ABSTRACT

Based on the conditions of aquatic fauna in Segment 15 of the South Platte River established in previous studies by various government agencies, the USEPA has required the District to improve the quality of its secondary effluent. The staged improvements are 1) to reduce the total residual chlorine in the effluent to 3 ug/L by October 1, 1988, and 2) to meet seasonal limits on ammonia nitrogen by November 1, 1990, ranging from 10 mg/L during the summer months to 15 mg/L during the winter months .

USEPA also required the District to implement a stream monitoring study through its NPDES Permit that includes the collection of benthic macroinvertebrates as well as other parameters indicative of water quality. In addition to the stream monitoring study, the District has initiated its own "Incremental Assessment" of the benthic community inhabiting Segment 15. The objective of this program is to document, in three phases, changes that may occur in the benthic macroinvertebrate and piscine communities of Segment 15 due to the staged improvements of the District's effluent. Phase I was initiated in 1986 to gather baseline data on the benthic community to document structural characteristics of the community in the presence of high concentrations of residual chlorine and ammonia nitrogen. Data collected since then, Phase II, reveal changes that have occurred in the virtual absence of chlorine, but in the presence of ammonia nitrogen. Phase III will begin November, 1990 after the District comes into compliance with the ammonia nitrogen standards.

The NPDES and Incremental Assessment data show definite improvements in the benthic community of Segment 15 subsequent to dechlorination. Both the density and diversity of the insects have increased at the study sites downstream of the District's outfall. It is also evident from past and current data that the benthic community has been and continues to be impacted by nutrient enrichment. The macroinvertebrate community immediately downstream of the outfall is dominated by tubificid worms. Moving farther downstream, the community generally increases in diversity and evenness, indicating that nutrient enrichment is having less of an effect.

Both the NPDES stream monitoring and Incremental Assessment programs are ongoing and continue to provide valuable information on the conditions of aquatic life in Segment 15. Data collected from these studies have demonstrated the detrimental effects of chlorine on aquatic benthic communities, and hopefully will help us gain more insight into the effects of nitrogenous compounds on aquatic life. These achievements may provide the District and other municipalities reason and motivation to find better ways to manage municipal and industrial wastes, resulting in decreased impact on aquatic ecosystems.

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Use of the index of biotic integrity to assess fish community response in the South Platte River- Segment 15 to staged improvements to secondary effluent quality at a wastewater treatment plant.

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ABSTRACT

The Metro Wastewater Reclamation District through its 1986 NPDES Permit is required to construct and operate facilities that would reduce total residual chlorine (TRC) to 3 ug/L in the final effluent, and to build nitrification facilities to reduce the amount of ammonia being discharged to the South Platte River. Compliance with the effluent limit for TRC was effective October 1, 1988 and the ammonia nitrogen effluent limitations are to be achieved by November 1, 1990. Ammonia nitrogen levels are seasonal limitations with concentrations of total ammonia nitrogen ranging from 10-15 mg/L. Stream standards for un-ionized ammonia, the toxic fraction of total ammonia is 0.1 mg/L in Segment 15.

A biological sampling and monitoring program was established in 1986 to asses the status and trends occurring in the fish community as a result of improved effluent quality being discharged to the South Platte River. Eight sampling locations were selected in Segment 15 based upon similar habitat. In addition, the fish community in Clear Creek, a tributary to the South Platte River was also surveyed to determine its suitability as a reference reach.

The fish community at each location was sampled by electrofishing a 100 meter section with multiple passes. Capture data (weight, length, etc.) were input into the MICROFISH computer program for analyses. Results from these analyses were used to assess the biological integrity of the fish community in Segment 15. The Index of Biotic Integrity (IBI) was used to evaluate the incremental improvements, if any, that were occurring in the fish community. The IBI is a broadly-based ecological index that has acceptance by fisheries biologists nation wide. The IBI was originally developed to assess the integrity of streams in the midwest; however, the metric can be modified to reflect regional ecological conditions. The IBI used in these analyses follows those metrics adopted by Fausch at Colorado State University for Colorado front range rivers.

The IBI results from the District's sampling program shows a significant improvement in the fish community after dechlorination, and that the fish community in Segment 15 has stabilized. The IBI scores for Segment 15 are comparable to those observed in Clear Creek, and other front range streams (St. Vrain Creek, Big Thompson River). Although the IBI scores for Segment 15 are reflective of other riverine systems which are not severely impacted by chlorine or ammonia, higher IBI scores were observed at certain stations, suggesting that parameters other than water quality (i.e., habitat) may be limiting the biological integrity of the fish community in Segment 15.

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Measuring the effect of human perturbations on fish communities in three transition-zone tributaries of the South Platte River.

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ABSTRACT

Transition zones streams of the South Platte River Basin, which lie between the mountains and plains zones, provide unique habitats for fish such as the glacial relic species common shiner (*Notropis cornutus*) and redbelly dace (*Phoxinus* sp). However, because the major population centers are also in the transition zone, human disturbance ranging from early water withdrawal and floodplain farming to recent rapid development have degraded habitats for fish. Data from an ongoing sampling program at 18 sites in the transition zones of the Cache la Poudre and Big Thompson Rivers and St. Vrain Creek have been used to assess the effects of sewage treatment plant (STP) effluents, flow fluctuations, and channelization on the biological integrity of fish assemblages. Preliminary analyses indicate that channelization is likely to have the strongest effects on fish communities, whereas STP effluents have variable effects which are difficult to separate from the effects of degraded habitat at the resolution of the sites monitored. Flow fluctuations are difficult to analyze because flows vary widely between discharge gauges due to water withdrawal and irrigation return flow. A major flood, however, had little apparent effect. Estimating the relative importance of these three perturbations will require better data on fish assemblages near STP outfalls and in reaches with and without suitable habitat, as well as on flow fluctuations at specific points. The most needed action to increase fish habitat is better management of riparian zones to increase streamside vegetation that binds stream banks and large wood debris that falls into stream channels.

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The Boulder Creek watershed non-point source pollution control and water quality monitoring programs.

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ABSTRACT

The Boulder Creek Watershed Nonpoint Source Pollution Control Project extends from the Indian Peaks Wilderness headwaters to the confluence with Coal Creek, a creek mainstem length of 40.8 miles. Project objectives include: 1) control of NPS pollution using state-of-the-art BMPs, 2) provide cost-effective water quality improvement singly and in combination with the WWTP, and 3) achieve the state use classification (Class 1 WW Aquatic Life) in the lower basin.

The watershed has been divided at the Boulder Canyon mouth into an upper (mountain) basin and a lower (plains) basin. Upper basin pollution includes: 1) 16 miles of highway sanding operations (3,000 tons/year including 7.5% salt), 2) mineral and gravel mining, and 3) sediment from a 1989 forest fire on Sugar Loaf Montain. Lower Basin pollution includes: 1) road sanding operations (15,000 tons/year including 15% salt), 2) NPS drainage (18 sources) such as irrigation ditch return flows and 30 to 40 storm sewers, 3) channelization (70% requiring 7.8 miles of berm removal), 4) streambank erosion (72 locations totaling 2.1 miles), 5) overgrazing and gravel mining resulting in loss of riparian zone function.

The City of Boulder has conducted an ongoing Boulder Creek water quality monitoring program since 1982. Data analysis of samples from several stations downstream of the WWTP between 1982 and 1985 revealed periodic exceedances of water quality standards for several parameters. However, it was not always clear if the exceedances were caused by episodic nonpoint source (NPS) pollution or the WWTP point source. Subsequently, a 12-month use attainability study was designed and conducted which confirmed a prior consensus that the aquatic life use was not being attained and could not be attained in a 20-year period because of NPS pollution and habitat degradation. Follow up studies included a one year, biweekly, 24-hour sampling study and two 24-hour synoptic studies during known unionized ammonia excursion periods (Windell et al. 1988a, 1988b, 1987a).

Data indicated unionized ammonia excursions primarily during spring and fall and during daylight between 10:00 A.M. and 6:00 P.M. It was revealed that excursions did not necessarily occur during times when there was highest concentration of total ammonia in the creek, but rather when pH and temperature conditions favored conversion of total ammonia to the un-ionized form. Therefore, the amount of un-ionized ammonia in the stream during daylight hours is a function of the amount of total ammonia converted and amount of total present. When pH and temperature conditions are optimum, excursions occur seasonally (spring and fall) and daily during the seasons. Elevated water temperature in the spring and fall is a function of solar radiation, air temperature, and day length while elevated pH occurs when plant life is abundant and carbon dioxide is extracted from the water during the hours of photosynthesis. Length of an excursion period appears variable from year to year and may be strongly influenced by discharge during low and high flow water years.

An ongoing basin wide monitoring program is providing data to determine successes or failures of the implemented Best Management Practices (BMPs). Reported observations and documentation indicated that a final water quality management plan for the basin should include point source and NPS pollution controls. Neither control type alone can result in a stream that consistently meets its intended uses or water quality standards. Recommended BMPs will permit NPS pollution control, result in physical, biological and chemical habitat reclamation, and facilitate attaining the aquatic life use in the lower basin.

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Preliminary environmental contaminant survey of the South Platte River in northeastern Colorado, 1988.

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ABSTRACT

A preliminary reconaissance survey of environmental contaminants was conducted in the South Platte River starting near Henderson, Colorado and ending near Julesburg, Colorado during July of 1988. Composited grab samples of bottom sediment, filamentous algae, crayfish and two taxa of fish(mixed species of shiners combined and common carp) were collected at seven sites located 43 to 65 km apart. One composite sample of each matrix was taken at each site. Samples were taken at sites near: Henderson (site 25). Millikin (site 26), Masters (site 27), Snyder (site 28), Sterling (site 29), Crook (site 30), and Julesburg, Colorado (site 31). Shiners were not available from site 25 and crayfish were not available from sites 25, 28 and 30. All samples were analyzed for inorganic constituents. Data for eleven elements are reported including: aluminum, arsenic, barium, copper, iron, mercury, magnesium, manganese, selenium, strontium, and zinc. Samples of sediment, crayfish, shiners and carp from sites 26, 29 and 31 were analyzed for organochlorine pesticides and polychlorinated biphenyls. Samples of sediment and shiners from sites 26, 29 and 31 were analyzed for organophosphate and carbamate insecticides.

Trace amounts of chlordane isomers (three compounds) and DDT isomers (three compounds) were found in crayfish and fish from sites 26, 29 and 31. The only single compound that exceeded 0.02 ug/g (wet basis) was p,p'DDE (DDE). Concentrations of DDE in carp from the three sites varied from 0.06 to 0.17 ug/g, in shiners they varied from 0.05 to 0.29 ug/g and in crayfish they varied from <0.01 to 0.06 ug/g. Concentrations of organophosphate and carbamate insecticides did not occur above detection limits.

Concentrations of inorganic constituents (dry basis) in samples of sediment and fish were compared to baseline concentrations established for soils of the western United States and for fish from the United States. Elements in sediment samples that averaged greater than an averaged established mean for western U.S. soils were copper and selenium. Elements that on average exceeded the 85th percentile for whole fish established in a survey of the U.S. were copper, selenium and zinc.

Elemental concentrations in biotic samples were not consistent. Between the two fish groups and across all sampling, shiners had higher average concentrations of arsenic, aluminum, iron, strontium, and manganese while carp had higher average concentrations of copper and zinc; concentrations of other elements were similar for both groups. Crayfish had average concentrations of aluminum, barium, arsenic, copper, iron, strontium, and magnesium that exceeded that in all fish while selenium and zinc concentrations were higher in fish. Other elements were similar in fish and crayfish. Concentrations of aluminum, barium, iron, magnesium, and arsenic in algae samples exceeded those in both the fish and crayfish samples.

Further analysis was done to examine trophic relationships indicated by the data. Predictably, concentrations of aluminum, arsenic, barium, iron, magnesium, and manganese were higher in sediment and algae than in crayfish or fish. This pattern is inconsistent with the food chain effect which would follow a pattern of increasing concentration at higher and more advanced levels in a food chain. Conversely, concentrations of copper, mercury, selenium, strontium and zinc were higher in both crayfish and fish than in algae or sediment. This pattern is consistent with the food chain effect.

The sampling sites where the highest concentration for each of the elements in each matrix were summarized. Several points can be made from this analysis. For shiners, all of the highest concentrations for each element occurred at sites 29, 30 or 31. In sediment the highest concentrations of nine elements were found at site 27, and only two elements were at the highest concentrationat site 30. The highest concentrations of 10 of the 11 elements in algae were found at sites 25 and 26, and only one element was highest at site 30. The highest concentrations of elements in carp and crayfish occurred at four sites.

(continued next page)

Concentrations of copper, mercury, selenium, strontium and zinc (elements that demonstrated a food chain effect) in sample matrices were compared with similar data for those matrices obtained from the Arkansas River during the summer of 1988 at seven locations starting near Pueblo, Colorado and ending near Garden City, Kansas. Copper concentrations averaged higher in samples of carp, crayfish and sediment but were similar in shinersfrom the South Platte River compared with similar samples from the Arkansas River. Mercury concentrations in samples of shiners and common carp from the South Platte River were on average higher than those in the Arkansas River. Mercury concentration is samples of crayfish and sediment were similar between the two rivers. Concentrations of selenium and strontium in biological samples from the South Platte River were generally lower than in the Arkansas River. For zinc, concentrations in the South Platte River were similar in fish and they were generally lower in crayfish than in the Arkansas River.

In summary, three of the 11 inorganic elements (copper, selenium and zinc) represented the greatest number of exceedences in samples of fish and sediment taken from the South Platte River. Selenium exhibited the greatest deviation above baseline in fish and copper while zinc deviatedthe most above baseline in sediment. A food chain effect consistent with the process of biomagnification trends was observed for copper, mercury, selenium, strontium, and zinc. Upstream/downstream trend analysis of 11 elements indicated relatively high concentration in algae at the upper end of the study area; in shiners at the lower end; and, in sediments in the central part (particulary at site 27 near Masters). Elemental concentrations in crayfish and carp did not demonstrate any consistent pattern of contamination. For sampling among the four sites from which all matrices were obtained (sites 26, 27, 29 and 31), sites 26 and 27 were the most contaminated followed by site 31 and site 29.

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Fisheries of the South Platte River in Colorado.

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ABSTRACT

Historically, the South Platte River was characterized by two distinct types of fisheries, mountain and plain. The native trout, greenback cutthroat trout, along with longnose and white suckers, characterized the mountain portions of the South Platte River. Historical accounts indicate fishing was good, but no data exist for comparison to today. On the plains, the South Platte River contained minnows and other species of small fishes adapted to the wide fluctuation in flow between spring runoff and the low flow season in fall and winter.

At present, the two types of habitat are still present, but the species composition has changed. Brook, rainbow, and brown trout now inhabit the mountain portions of the South Platte River along with suckers. The plains habitat still contains minnows, but also contains introduced species such as sunfishes, carp, and black bullheads.

From Lake George downstream to Cheesman Reservoir, the South Platte contains trout, with standing crops in the 50-100 lbs./acre range. Special regulations are in effect, but the habitat is only fair, keeping biomass in check. Downstream of Cheesman Reservoir, the combination of special regulations, good habitat and releases from Cheesman Reservoir combine to produce very high trout biomass. The effects of special regulations are evident in the section of the river from Cheesman Dam downstream to the North Fork. Biomass in this section has increased substantially since the regulations have been implemented.

Downstream of Strontia Springs Reservoir, there is again the combination of good habitat, special regulations and dam releases that result in high biomass. Further below the dam, in the standard fishing regulations section of Waterton Canyon, biomass is considerably lower. Downstream of Chatfield Dam the river is channelized through Metro Denver. The species composition changes from the trout/sucker community of the mountains to the minnows and introduced species of the plains. In addition water quality and habitat changes as the river flows through the metro area result in much lower fish biomass and fewer species than expected.

Little recent sampling has been conducted on the South Platte River on the plains. However, work conducted in 1968 indicates the populations are comprised of minnows, carp, sunfishes, and other introduced species. Sampling of the South Platte and Platte River in Nebraska indicates a higher species density in Nebraska than in Colorado. Game fish in the South Platte River in Nebraska are generally restricted to limited habitats such as bridge pilings, temporary ponds, sloughs, and backwaters. This is probably also true in Colorado.

The future fisheries will be determined by management (regulations and stocking), changes in habitat and water quality, and flow schedules.

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History and current status of fish populations of the South Platte River, Southeast Region DOW .

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ABSTRACT

The northern boundary of the southeast region of the Colorado Division of Wildlfe is located along the Park County line with Douglas and Jefferson counties. This is about 2 miles south of Cheesmen Reservoir on the South Platte River. There are about 40 miles of river and two mainstem reservoirs (Elevenmile, 3300 acres (Denver), and Spinney Mountain, 2000 acres (Aurora)) on the South Platte between the regional boundary and the confluence of the Middle and South Forks of the South Platte River. The South Fork of the South Platte has one impoundment, Antero Reservoir (about 2000 acres (Denver), located about 8 miles above the confluence. The Middle Fork has a small reservoir (Montgomery, 100 acres) about 6 miles above Alma, which is generally unregulated. Another major tributary is Tarryall Creek, which has two impoundments of about 150 acres, Tarryall and Jefferson Reservoirs. Land use of the area is primarily grazing and mining. Much of the stream habitat is considered poor in South Park due to overgrazing. Mining has resulted in degraded water quality and stream habitat in some sections of the upper portions of the Middle Fork. The South Platte system of the southeast region between Lake George and Highway 285 is a major fishery and recreational area. The DOW has designated the river from Elevenmile Reservoir to Fairplay on the Middle Fork and Antero on the South Fork, including Spinney Reservoir as Gold Medal Fishing. This designation denotes the best fishing areas of the state and always includes the use of restrictive fishing regulations. Put-and-take management is used on Elevenmile, Antero, Jefferson, Tarryall, and Montgomery Reservoirs, and on the river in Elevenmile Canyon, above Fairplay, and in the South Fork below Antero. The most common native fish species in the South Platte include white and longnose suckers. Creek chub and longnose dace have been collected from the Wildcat Canyon area. Johnny darters have been found in northern pike stomach from Elevenmile Reservoir. The native trout, greenback cutthroat trout, has not been reintroduced into the Platte drainage in the southeast region. Most of the present fish found throughout the system up to about 9500 feet elevation. Brook are generally restricted to about 9500 feet and cutthroat are found in the upper parts of the headwaters, and Snake River cutthroats have been stocked in Spinney and Elevenmile reservoirs. Other species primarily found in reservoirs include northern pike, carp, rainbow trout, and kokanee salmon. Lake trout are found in Jefferson Lake. Fishermen use is very heavy in the tail water area below Spinney and Elevenmile Reservoirs. Fisherman use on all reservoirs is considered as heavy.

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Session III.

Wildlife Along the South Platte River

Ecological succession and conservation confusion in the South Platte floodplain.

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ABSTRACT

Despite extensive water development, peak and annual flows in the lower South Platte River resemble historical patterns. The river now has enhanced low flows during late summer months, and those flows have led to extensive vegetative development in eastern Colorado. Cottonwoods (*Populus sargentii*) established within the floodplain earlier in the century and secondary successional tree species, especially Russian-olive (*Elaeagnus angustifolia*) and ash (*Fraxinus pennsylvanica*), are now colonizing rapidly. Floodplain vegetation that were historically regulated by pulsed flows are now primarily driven by ecological processes. The invading deciduous vegetation provides local habitats for greater wildlife diversities than currently found elsewhere (or historically) in the state. Currently, 82% of all bird species breeding in Northern Colorado use riparian zones of the South Platte. Some species of birds and mammals are only found at upper locations in the drainage. Most species in the lower portions of the drainage are ecological generalists, many having recently invaded the state's eastern plains from Nebraska. Integration of management of the South Platte system must address the issue of the imposing faunal mixing currently being experienced on the eastern plains. Agency bureaucracy, rather than actions of individual agencies, is currently making most wildlife conservation policy in the South Platte drainage.

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Inventory of wildlife habitats along the South Platte River.

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ABSTRACT

Photo interpretation (contracted to the Colorado State Forest Service) was used to monitor 36-year (1940's to 1979) changes in area occupied, canopy cover, and age class of trees [primarily plains cottonwoods (*Populus sargentii*)] and changes in other cover types along the South Platte River in northeastern Colorado. Data were taken from a random sample of 29 river-mile units (18%) from Greeley east. Stands of cottonwoods declined from 62.3 to 56.5 ha/river mile (9.3%, $P = 0.05$) during the 36-year interval. Young trees (10% of the initial composition) declined 33.6% ($P = 0.09$) during the 36-year interval. Intermediate age classes approximated 88% during both samples. Open stands dominated during both inventories; a reduction in closed stands occurred, but no pronounced trend toward dramatic opening of stands was identified. Based on these data, a modest overall decline in cottonwoods occurred. Early to recent declines were observed in shrubs (-20%) and hay meadow (-45%), whereas increases occurred in grassland (+206%), cropland (+117%), and developed land (+229%). Several floods in recent decades are believed responsible for channel widening (+73%, $P < 0.05$). Trial efforts using stem cuttings to artificially propagate cottonwoods and other trees/shrubs within the South Platte River floodplain were not successful because of groundwater fluctuations. Photo interpretive sampling should be continued at 10 to 20-year intervals to monitor vegetation changes with potential impacts on wildlife.

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Deer population density and habitat use along the South Platte River in eastern Colorado.

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ABSTRACT

Fifty-six radio-collared deer (30 mule deer and 26 white-tails), captured in the South Platte River bottom between Platteville, Colorado, and the Nebraska State Line, have been located by aerial telemetry at approximately 2-week intervals for 3 1/2 years. The study is still in progress.

The radio-collared deer appear to fall into 4 movement categories: Movement category 1: Deer which remain in or near the river bottom throughout the year and occupy a segment of river bottom from 2 to 20 km in length. Movement category 2: Deer which remain in or near the river bottom throughout the year, but travel relatively long distances (30 to 120 km) up or downstream. Movement category 3: Deer that spend most of the year, including winter, in or near the river bottom, but during late spring or summer they leave the river bottom and spend at least several weeks out on the plains. These then return to the river bottom. Movement category 4: Deer that, after being captured and marked in the river bottom during winter, move out onto the plains and are either rarely or never again located in the riverbottom as long as they are monitored. All 4 categories have radio-collared deer of both species except for category 2 which has no radio-collared mule deer. Most of the radio-collared deer are in category 1 with category 3 ranking second. Categories 2 and 4 contain relatively few animals.

Riparian vegetation has been the habitat type most commonly used by both species of radio-collared deer. It is the dominant habitat type in the South Platte river bottom and is characterized by cottonwoods (*Populus sargentii*), willows (*Salix* spp.) and various tall species of grass and forbs. On the adjacent plains it is found along creeks, canals, and around ponds and lakes. Other habitat types frequented by deer, when they are away from the riverbottom and out on the plains, include abandoned fields covered by annual weeds, grassland, sand sagebrush (*Artemisia filifolia*), wheat stubble and milo stubble. Members of both species of radio-collared deer have often been located in cornfields during July through October.

An experiment was conducted in January and February, 1989, to measure accuracy of deer counts. Deer in the South Platte river bottom between Platteville, Colorado, and the Nebraska State Line were counted and classified by species, sex, and age (3 times by 2 observers in a helicopter). The entire stretch of the river was flown on the first count. Counts 2 and 3, however, were limited to certain river segments where radio-collared deer occurred. In addition to counting the total number of deer seen, observers also recorded the number of radio-collared deer. While counts by helicopter were in progress, radio-collared deer were located by fixed-wing aircraft, so the number of radio-collared deer in the census area was known. Observers in the helicopter saw an average of 93% of the radio-collared mule deer and 69% of the radio-collared whitetails on the 3 counts. These data can be used to adjust upward the total number of deer seen in order to allow for those deer the observers missed. Data from count 1, adjusted for missed deer, suggest an estimated correct population, in the South Platte Riverbottom between Platteville, Colorado, and the Nebraska State Line, of 1890 white-tailed deer and 529 mule deer. On count one, 25 white-tail bucks and 24 mule deer bucks were counted per 100 does. Fawns counted per 100 does were 74 for white-tails and 88 for mule deer. Knowledge of the proportion of deer seen during counts, provided by this study, will facilitate a better population estimate and more precise management of deer along the South Platte River in eastern Colorado.

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Winter habitat use by mallards in the South Platte River Basin.

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ABSTRACT

The South Platte River Basin provides ducks with the most important breeding habitats (North Park, Platte Valley), molting wetlands (North Park), migratory stopover areas (North Park, South Park, Platte Valley), and wintering sites (Platte Valley) in Colorado. Whereas numbers of breeding and molting ducks have remained stable, populations of wintering ducks (95% mallards) in the Platte Basin east of the Front Range have declined from an average of 170,000 in the 1970's to 93,000 in the 1980's. Although related in part to reduced continental mallard populations, the percentage decline in wintering mallards in the Platte Basin between these periods (45%) greatly exceeds the decline in the continental mallard population (21%). This decline, coupled with wetland losses and general habitat degradation in the South Platte Basin, suggests a deterioration in the winter carrying capacity for ducks in this important region.

During winters of 1986-87 through 1988-89, we radio-marked 86 mallards to monitor habitat use, movements, and behavior within a 1,089 km^2 study area near Greeley, Colorado. The study area included 4 rivers (South Platte, Cache la Poudre, St. Vrain, and Big Thompson) and 367 wetlands totaling 1,266 ha. For analyses of habitat selection, wetlands were classified as small ponds (<40 ha), lakes (>40 ha), holding or sewage lagoons, gravel pits, warm-water wetlands, ditches, and rivers. Eighty hours of focal animal time budgets were obtained on selected wetland classes to aid in interpreting habitat preferences. A total of 3,593 telemetry locations were used in habitat selection analyses.

Winter home range sizes averaged 119 km^2, but ranged from 4 to 400 km^2 among individual birds. Immature mallards had larger home ranges than adults. Daily movements of >10 km were common. Average home range sizes in 1986-87 (150 km^2), 1987-88 (124 km^2), and 1988-89 (84 km^2) differed in relation to weather conditions; larger home ranges occurred during warm winters. Mallards used small ponds and lakes when they were not frozen, but switched to warm-water wetlands during severe weather. Overall, warm-water wetlands (sloughs and seep ditches), which composed only 0.6% of the wetland habitat, were strongly preferred during winter. Sex- and age- specific habitat preferences were also apparent: adult males used warm-water wetlands more than other age-sex classes, females used lakes more often, and adults used rivers more than immatures. Resting, swimming, and preening were the dominant winter behaviors. Lakes were used more frequently for courtship, rivers were used more for feeding, and warm-water wetlands were used more by resting and roosting ducks.

Mallards respond to a hierarchy of habitat selection that, at its highest level, is dependent on the availability of ice-free wetlands weighted by important disturbance factors such as hunting. When weather allows, mallards prefer lakes and small ponds over rivers, lagoons, and ditches. Under snowfree conditions, mallards prefer to feed in cornfields rather than cattle feedlots. However, mallards show a plasticity in their response to these and other conditions, adapting their movements and behavior to short-term weather events. Temporal and spatial variability in habitat use also relate to social events that occur during winter. Most mallards establish pair bonds during mid-winter in Colorado, and wetlands such as lakes are used as "courtship arenas" for locating a mate. Once a mate is selected, paired birds isolate themselves on ditches and small pockets of open water, and feed in rivers and other wetlands with open water. Warm-water sloughs are the most critical and limiting wetlands for wintering mallards, as well as the wetland class most prone to hunting disturbance. More research is needed on ways to manage disturbance, as well as techniques to create and restore these sensitive wetlands.

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Grazing in the South Platte floodplain — Just a matter of timing.

Fritz Knopf
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ABSTRACT

Grazing of streamside vegetation by livestock is considered the most universal threat to wildlife habitats in the West. Cooperative studies conducted by FWS National Ecology Research Center, the Colorado Division of Wildlife, and Colorado State University in the 1980s indicate that cattle can be managed within riparian areas without precluding wildlife interests. The studies included both an evaluation of historical grazing practices on homesteads along the Illinois River in North Park and an experimental introduction of cattle into a healthy riparian community on the South Platte Wildlife Management Area at Crook. Together the studies indicate that streamside vegetation can be grazed late in the growin season or during the dormant season with little impact upon native bird habitats. Cattle impacts upon floodplain vegetation are moderated in this season due to reduced soil compaction, stabilized streambanks, the seasonal phenology of the deciduous vegetation, and supplemental forages not available during the growing season.

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Session IV:

Vegetation and Habitat Research along the South Platte River

Development of assessment methods for hydrologic impacts on western riparian ecosystems.

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ABSTRACT

Water management in the arid and semi-arid west is the key factor influencing the nature and extent of riparian ecosystems. Natural resource agencies must be in a position to anticipate and predict the impact of water management decisions on important riparian habitat. These efforts have been hampered, historically, by our inability to quantitatively link ground and surface water hydrologic events and patterns with the physiologic and ecologic requirements of the dominant plant species in plains riparian communities.

The U.S. Fish and Wildlife Service's National Ecology Research Center has identified western riparian ecosystems as a major focal point for research and development activities. The Inland Freshwater Ecology Section has developed a multi-year strategic plan aimed at defining the relation between surface and groundwater hydrology and the maintenance and establishment of woody riparian plant species. The depth, duration, and timing of flood events are essential to understanding the dynamics of seed germination and the establishment of woody tree species in riparian corridors. Similarly, the depth to groundwater and the influence of, and interaction between surface water discharge and groundwater are important to the maintenance of existing riparian stands. Many of these relations have not be thoroughly quantified or documented experimentally in western riparian ecosystems. The subject research and development effort is designed to document many of these relationships for several plains riparian species and communities through a combination of experimental mesocosm studies and instrumented field sites within the South Platte River Basin, CO.

The ultimate goal of these research studies is to develop data sets that can be used in refining hydraulically driven riparian vegetation models that would describe the effects of flow alteration on the maintenance and establishment of important riparian species along hydrologic gradients. These models will be central to the development of an assessment method for hydrologic impacts on riparian ecosystems. Detailed descriptions of these ongoing research efforts are presented elsewhere in this document.

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Predictive models of riparian vegetation response to altered streamflow.

Gregor T. Auble, M. L. Scott, L. J. Martin, L. S. Ischinger, and C. A. Segelquist
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ABSTRACT

Several types of models have been used to predict riparian vegetation change including compartmental and individualistic dynamic simulation models and regression models relating discharge to tree growth rate and width of the riparian zone. We are evaluating three models that might be used in conjunction with the Instream Flow Incremental Methodology that was developed for assessing impacts on fish habitat. The first is a direct gradient analysis of existing vegetation that establishes species preferences along a gradient of inundation frequency. Alternative flow regimes are then evaluated in terms of how the areas most suitable for various species change under alternative flow-duration curves. The second defines hydrologic criteria for the establishment of species at various positions along hydraulic cross sections. A hydrologic regime is then evaluated in terms of where and how often these conditions are satisfied. We are currently implementing this approach for cottonwood through both experiments and monitoring. Lastly, we are addressing groundwater mediated effects of flow alteration by classifying zones according to the relative dependence of groundwater levels on discharge. Potential changes in groundwater levels within these zones can then be compared to maximum changes tolerated by mature trees. These three approaches are closely coupled to the hydraulic water surface elevation models from the Instream Flow Incremental Methodology.

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Hydrology of a riparian forested area on Boulder Creek.

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ABSTRACT

A study of the relation of woody riparian vegetation to hydrologic conditions in the riparian zone of Boulder Creek was initiated by the USFWS in the summer of 1989. The study site is in Cottonwood Grove, part of the Boulder Open Space between Foothills Parkway and 55th Street. Water levels in 22 groundwater wells are being monitored on a weekly to monthly basis. A streamflow recording gage is in place and stage-discharge measurements have been made to establish a rating curve.

Cottonwood Grove is underlain by 10-15 feet of alluvial deposits, consisting of coarse sand to cobbles. Underlying the alluvium is the relatively impermeable Pierre Shale. The hydraulic conductivity of the alluvium was estimated from measurements of fluctuations of water levels in monitor wells adjacent to the creek in response to water level fluctuations in the creek (Ferris, 1951). The hydraulic conductivity estimate obtained by this method is 1000-1200 feet per day, which is in close agreement with published values for these type of deposits (Todd, 1959 and Fetter, 1980).

The study site is bounded on the north by the Goose Creek floodway adjacent to Pearl Parkway. The floodway was constructed in 1986-87 and consisted of enlarging an existing ephemeral drainage to transport urban runoff from new construction in the area. The channel of Goose Creek was excavated approximately 10 feet. Groundwater levels in the vicinity of Goose Creek were lowered similarly. Groundwater flow patterns were changed by construction of the Goose Creek floodway. Previously, groundwater had flowed from both the south and north toward Boulder Creek and was discharged into the creek. Construction of the Goose Creek floodway created a new low point for local groundwater discharge and has lowered the water table under the northern two-thirds of the Cottonwood Grove. Groundwater now flows from south to north under the Cottonwood Grove to discharge into the Goose Creek floodway. Boulder Creek has become a losing stream in this reach. Water seeping from the creek forms a mound on top of the water table. The size of the mound varies directly with the stage of water in the creek.

Groundwater levels on the site respond in a predictable manner to local environmental changes. Water levels rise following rainfall and snowmelt events and decline in the spring and summer in response to water consumption by evapotranspiration of trees on the site. The water table fluctuates up to 3 feet seasonally under most of the study site. A streamflow gage has been operated by the USGS on Boulder Creek near Orodell for approximately 80 years. Much water is diverted from Boulder Creek between Cottonwood Grove and the USGS gage at Orodell. There is also input from several intermittent streams in the reach between the gage at Orodell and Cottonwood Grove. Diversion records from the Colorado State Engineer's Office are being used to establish a correlation between streamflow at Cottonwood Grove and the Orodell gage. This correlation will be used to estimate historic streamflow at Cottonwood Grove from streamflow records at Orodell.

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Predicting the response of woody riparian vegetation to changes in instream flows through integrated monitoring of stream hydrology and riparian vegetation.

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ABSTRACT

The establishment, growth, and mortality of woody riparian vegetation along a reach of Boulder Creek has been monitored for two years. Permanent vegetation plots were established in association with instream flow transects and groundwater wells that allowed direct ordination of the vegetation along a gradient of flooding, based on instream flow hydraulic models. We recognized three zones based on the variable influence of surface and ground water on the vegetation: (1) a surface-water inundation zone; (2) a ground water mediated zone; and (3) an unaffected zone (vegetation unaffected by surface-water). Within the surface-water inundation zone (active channel) we found a strong correspondence of vegetation (species and species groups) to hydraulic position and frequency of inundation. The establishment of cottonwood (*Populus fremontii*) and sandbar willow (*Salix exigua*) is limited to this zone. Woody exotics are important components of this zone. The ground water mediated zone and unaffected zone are similar with respect to ground water and vegetation. These zones are characterized by a high ground water table and the vegetation is dominated by the exotic crack willow (*Salix fragilis*) that persists by root sprouting; ash (*Fraxinus pennsylvanica*) and box elder (*Acer negundo*) dominate seedling and sapling size classes. Vegetation impacts here are likely to come from land use and ground water changes (not related to discharge). Identification of relations between surface and ground water and vegetation dynamics will provide better predictions of riparian vegetation response to changes in instream flows.

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Response of plains cottonwood seeds and seedlings to simulated hydrologic regimes of the riparian zone.

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ABSTRACT

In the spring and summer of 1990, we initiated a study to evaluate the relation of plains cottonwood (*Populus sargentii*) seeds and seedlings to simulated riparian groundwater hydrology of Front Range streams. The study is being conducted at the Bellvue-Watson Fish Hatchery adjacent to the Poudre River northwest of Fort Collins, Colorado. The objectives of this research are to experimentally determine rates of drawdown and levels of soil saturation for optimal cottonwood seed germination and seedling survival and growth. The results of this research will be integrated into a simulation model being developed to predict the effects of changes in streamflow and riparian groundwater, resulting from water management, on woody riparian vegetation. Cottonwood seeds were collected and planted in a series of 45, 30 cm x 100 cm PVC planters containing a substrate of saturated coarse sand. Planters were placed in 122 cm diameter galvanized steel tanks that were 91 cm deep. Water levels were controlled by adding or draining water from the tanks on a daily basis. Following planting, planters were subjected to one of five treatments: constant saturation, saturation for 7 days followed by a drawdown of 0.36 cm per day, saturation for 7 days followed by a drawdown of 0.71 cm per day, saturation for 7 days followed by a drawdown of 2.86 cm per day, and saturation at planting with immediate total drawdown. The experimental design consists of three replications of each of the five hydrologic/moisture regimes. Parameters measured included number of seeds germinating, number of seedlings surviving at weekly intervals throughout the growing season, shoot height of seedlings at weekly intervals, root length of seedlings growing in extra planters subjected to the same experimental treatments as those used for survival and height growth, and final shoot height, root length, and relative biomass for roots and shoots for all seedlings at the end of the growing season. Preliminary results will be discussed and presented in a slide talk. Visits to the study area will be arranged for those who are interested, following the formal meeting. We also intend to conduct similar studies for other species of woody riparian vegetation such as green ash, box elder, Russian olive, and perhaps selected species of willow in years to come.

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Ecology of riparian vegetation along mountain reaches of the Cache la Poudre River, a major tributary of the South Platte River.

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ABSTRACT

I studied the diversity and distribution of riparian plant communities along an elevational gradient from 1500 meters above sea level (5000 ft) to 3500 m (11,500 ft). 103 vegetation stands within 19 reaches were classified into 10 major riparian community types. I used valley width, channel type, fluvial geomorphic classes (e.g. streambank, active floodplain, and terrace), and surface texture as indicators of site hydrology and flooding history to determine controls of riparian community spatial distribution.

Results show that vegetation varied both within and between reaches. Within reaches (~100 meters of stream length), species composition and vegetation structure varied with height and distance from the active channel. Distinct riparian communities occurred on different fluvial landforms. For example, at low and mid-elevations, sapling Cottonwood (Populus deltoides and/or P. angustifolia)/coyote willow (Salix exigua) communities occurred on sand and cobble bars, while streambanks and overflow channels with finer substrates were dominated by Ponderosa pine (Pinus ponderosa)/alder-birch (Alnus incana and/or Betula occidentalis) communities.

Between reach variation in community composition was a function of elevation. Detrended Correspondence Analysis of woody species for all stands had first axis (greatest variation within data) scores that correlated strongly with elevation (R^2=0.826, $P<<0.001$). For example, plains cottonwood (Populus deltoides) is replaced by narrowleaf cottonwood (Populus angustifolia) at approximately 1850 m (6100 ft), coyote willow is replaced by Geyer willow (Salix geyeriana) at about 2600 m (8530 ft), while planeleaf and short-fruit willows (Salix planifolia var. monica and S. brachycarpa) dominate high elevation sites around 3300 m (10,800 ft).

Valley width, stream gradient, and variation in flow intensity control the rate of channel adjustment, and thus the variety of fluvial surfaces that occur across the valley floor (e.g. active floodplains, abandoned channels, and oxbow lakes). In broad U-shaped valleys where there has been continual lateral adjustment and reworking of the alluvium, there was a corresponding high diversity of riparian communities. In contrast, narrow, steep, bedrock confined V-shaped valleys constrict channel lateral movement and limit the type of fluvial surfaces present, and thus limit the diversity of riparian communities within a reach.

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Session V:

Water Management in the South Platte River Basin

South Platte Basin water management: Cooperative water management.

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ABSTRACT

This studies purpose is to define problems, needs, and concerns of water users within the study area; to identify both structural and non-structural solutions and alternatives for improved water availability; to define sound and equitable methods to finance the identified alternatives; to define those alternatives that would best preserve the environment and quality of life in the Basin, and; to implement alternatives needed to meet the needs of water users.

The study was begun in 1987 in response to the need to improve water management on the South Platte River. A South Platte Basin Water Management Committee and a Technical Support Subcommittee (TSS) was created to carry out the investigation at the local level. The TSS includes representatives from the four districts, the Bureau of Reclamation, Groundwater Appropriators of the South Platte, Inc. (GASP), South Platte Basin Water Coalition, Denver Water Board, Colorado Division of Water Resources, Colorado Water Resources & Power Development Authority and U.S. Geological Survey.

An Operational Advisory Subcommittee (OAS) was created to obtain input from additional water user groups in the basin. Seventeen entities make up the OAS. The intent is to have local entities conduct the study in order to keep it on the "grass roots" level. Water user interviews were conducted with 16 irrigation companies to obtain their input. In addition, extensive questionnaires were distributed to all cities, domestic water providers, and major industrial water users in the basin. Previous water resources studies have been reviewed to obtain as much existing information as possible. The Stream Aquifer Model for Management by Simulation and Optimization (SAMSON) developed by the Colorado Water Resources & Research Institute has been selected as a basis for simulating proposed alternatives and associated benefits.

The TSS will have a draft report for Phase I, Step I of the study available in the Fall of 1990. Phase I, Step I is a data collection activity and includes the results of interviews with the water users and an identification of water management problems. To date, $71,500 of federal funds have been expended and were matched by in-kind services of the local participants. Phase I, Step 2 of the study will investigate non-structural or minor structural solutions to identified water management problems. It will be necessary to conduct preliminary field investigations, data analyses, and computer model analysis to determine potential solutions. Phase I, Step 3 will investigate major structural alternative for those problems not solved by non-structural or minor structural solutions.

The project sponsors are: Central Colorado Water Conservancy District, Lower South Platte Water Conservancy District, Northern Colorado Water Conservancy District, St. Vrain & Left Hand Water Conservancy District, and the U. S. Bureau of Reclamation.

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Water management database for the South Platte.

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ABSTRACT

The South Platte and its tributaries make up the most densely populated hydrologic basin in the State of Colorado. In addition, the basin supports the irrigation of 1.3 million acres of productive farmland. With growing concern for improved water management, a central repository for water data in the basin needs to be established. Water users and agencies in the basin need ready access to information regarding the distribution, quantity, quality, and availability of water resources.

The needs for increased information management has led to the current project that is investigating implementing a federated database management system among water users in the South Platte Basin. This project will look at using telecommunication networks and connectivity software to tie existing databases among discrete water agencies within the basin together in order to enhance management and operations of the South Platte water system. A central server organization would act as a home base for system administration. Participating organizations will make use of existing computer hardware they own. This project will increase accessable data, decrease redundancy of storage, and increase water management potential. Long-term goals include implementation of expert systems for data checking, knowledge creation, and system management.

This project will prepare a detailed facilities and management plan for the development of a water database for the South Platte River Basin at Colorado State University, and also prepare a hydrologic data assessment report describing the current status of available and emerging water data in the South Platte Basin. The project is to be coordinated with the data-gathering activities by the State Engineer's Office.

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Development of a decision support system for water rights administration.

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ABSTRACT

The objective of this project is to develop a computer-based decision support tool to be used by the Colorado State Engineer's Office in the real-time administration of water rights. The tool will provide a centralized and unified means of rapidly accessing information about the current state of the hydrologic system and relating it to information about water rights and water use. Techniques for managing and linking spatial and relational data will be used both for analysis and for visualization of the essential elements of the administrative problem. The tool is intended to serve the needs of both administrators and water users by providing a medium for information sharing and communication, which can lighten the reporting burden and facilitate decision-making for all parties.

The goal of the first phase of the project is to develop a demonstration prototype encompassing the hydrologic and administrative region of the upper South Platte River basin, from a point above its confluence with St. Vrain Creek to its headwaters, including the tributaries of Cherry Creek, Plum Creek, Clear Creek, Bear Creek, Tarryall Creek, and the North, Middle and South Forks of the South Platte. Real-time operation of the system will be simulated by the use of records of data transmitted via satellite at hourly or fifteen-minute intervals for streamflow, precipitation, air temperature, snow water content, and transmountain diversions. Current water usage information will be simulated by the State Engineer's daily diversion records. The State Engineer's Tabulation of Water Rights is used as the source of information describing and relating water rights and diversion structures. Unofficial call records are used to simulate the history of administrative decisions.

The Phase I prototype will demonstrate the use of a map display with zoom-in capabilities as a means of presenting and accessing information related to particular measurement stations and diversion structures. In addition, the prototype will enable a user to specify a "call" by designating a point on the river and an administration number, i.e. a relative "priority" number. The prototype will support related operations, such as computing the net difference in impact of alternative calls upon upstream water rights, the identification of all structures with associated rights which would be affected by a call, and the display of all tributaries and reaches of the river which would be affected by different calls.

Phase II of the project, as planned, would address three primary goals. First, the tool would be made operational by implementing the data communication links and file structures to access and manage the flow of real-time data. Second, the geographical region encompassed by the system would be extended downstream to the Colorado State Line. Third, routing methods would be incorporated into the tool to enable it to compute temporal relationships and to partition computed flows into components of natural streamflow and non-natural flows, such as storage releases and imported water.

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Water management— Isn't there a better way?

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ABSTRACT

Currently the South Platte River system in Colorado is managed as many different irrigation and water management subsystems with separate structures for all bureaucratic and physical needs. This paper proposed that the South Platte Basin be managed as a whole ecosystem which includes man and his needs. After the Two Forks decision, the environmentalists have made it practically mandatory that the river be managed more efficiently.

Agricultural interests no longer care to see their farms being converted to golf courses or greenways. Fish and wildlife interests want to see system-wide management for their needs. Recreationists agree. Economic interests desire more water for development. The desire for better management is universal across users.

A study by Tudor Engineering Company on the Clear Creek Basin has shown that the basin has a firm yield of 16,100 acre-feet. If the basin was managed as a single unit, the firm yield could be increased to 44,000 acre-feet. The hypothesis is that this may be a similar finding for the entire South Platte Basin. If an alliance managed the entire basin, the firm yield would be increased.

If the South Platte were to be re-engineered for water management, ten objectives should be considered: 1) only one organization should be in charge of distributing the raw water resources, 2) priority of use should be determined by the constituents, 3) incentives for water conservation should be included in any plan, 4) conflicts should be reduced, 5) cooperative interfaces to other Colorado river basin districts should be maintained, 6) flexibility for change of use of water resources should be built in, 7) municipal water reuse should be optimized, 8) a groundwater recharge program should be developed, 9) the system should be operated to enhance recreation and environment, and 10) the system should be responsive to local government. The program could be brought into existence through use of C.R.S. title 43-Water Conservancy Districts.

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Other Research on the the South Platte River not Presented at the Conference

Opportunities for wetland mitigation banking on the South Platte River.

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ABSTRACT

Mitigation banking has been used in some regions of the country as a mechanism for compensating for the unavoidable impacts to wetlands since 1975. The Colorado Wildlife Commission, the recent memorandum of agreement on wetlands mitigation between the Corps of Engineers and Environmental Protection Agency, and the Domestic Policy Council's Task Force on Wetlands have all mentioned mitigation banking as a potential mechanism for compensating for unavoidable impacts to wetland resources. An effort is presently underway in Colorado to draft a statewide mitigation policy.

One of the concerns in adopting a mitigation banking policy for impacts to wetlands in Colorado has been the lack of examples of the technical feasibility of successfully creating large wetland systems. An example of such a system that has existed for approximately 13 years occurs on the South Platte River near Orchard, Colorado. Approximately 500 acres of wetland and aquatic habitat was created from 1,200 acres of upland sand hill habitat along the South Platte River. This successful wetlands creation effort indicates potential for other large scale wetland creation efforts along the South Platte River and a potential application for wetland mitigation banking in the region.

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Impacts of 1983-84 high water on cottonwood - green ash regeneration.

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ABSTRACT

Sustained high stream flows in 1983-84 (the greatest sustained volume in 80 years) facilitated extensive natural establishment of plains cottonwoods (*Populus sargentii*), green ash (*Fraxinus pennsylvanica*), and other woody species along the South Platte River in northeastern Colorado. Cottonwood seedling survival was monitored within 25 random stands of seedlings, and cottonwood and green ash seedling density was monitored within 30 extensive (>100 m) transects. Although first-year (Sep. to Sep.) survival was low (2.2%), annual survival of the 1983 cottonwood seedling cohort increased to 47, 79, 78, and 89% respectively over the next 4 years yielding an overall survival rate of 0.6%. Survival of the 1984 seedling cohort was 20, 66, 79, and 43% during their first 4 growing seasons. Cottonwood seedlings remained within 18 of 25 (72%) transects in fall 1988 indicating survival was distributed extensively within the floodplain. Green ash seedlings were in more open stands and established more slowly than cottonwoods. By fall 1988, 44 green ash seedlings/ha and 39 cottonwood seedlings/ha remained alive 5 - 6 growing seasons after 1983-84 high stream flows. In fall 1988, seedling density (83/ha) exceeded that of young to mature age classes (all tree species, 81 trees/ha) suggesting 1983-84 high stream flows contributed significantly to future stands of trees along the South Platte River. Flood conditions similar to those in 1983-84curtail natural reproduction of woody phreatophytes and disturbance essential for seed producing wild annuals, while promoting perennial grasses of limited value to wildlife. Habitat modifications to supplement naturally occurring habitats for bobwhite are feasible, but it is not economically practical to create new habitats once riparian habitats are lost.

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Northern bobwhite in eastern Colorado riverbottoms.

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ABSTRACT

The South Platte and Arkansas rivers are the primary locations sustaining huntable populations of northern bobwhites (*Colinus virginianus*) in eastern Colorado. The South Platte riverbottom usually supports higher densities and greater populations of this species even though winter weather is more favorable along the Arkansas River. Whistling call-count indices show higher densities consistently occur above than below John Martin Reservoir along the Arkansas River. These differences are primarily attributed to long- term habitat changes caused by construction of the reservoir. Past studies indicated northern bobwhite, like many other wildlife species, were dependant on seral vegetation conditions and an abundance of food-producing annual vegetation closely associated with woody cover. Sites dominated by woody cover - perennial grass associations were avoided by wintering bobwhite. Alluvial deposition, scouring, and sustained inundation during 1983 flooding severely impacted herbaceous vegetation within the South Platte River floodplain. During the 4 subsequent years (1984-87) perennials, primarily grasses, gradually recovered increasing from 37 to 57% occurrence, whereas annuals and biennials, abundant after flooding, declined from 34 to 10% occurrence. Thus, flooding along the South Platte River increased and helped sustain the food base for northern bobwhite and other wildlife. Dewatering and flood control curtail natural reproduction of woody phreatophytes and disturbance essential for seed producing wild annuals, while promoting prennial grasses of limited vallue to wildlife. Habitat modifications to supplement naturally occurring habitats for bobwhite are feasible, but it is not economically practical to create new habitats once riparian habitats are lost.

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Impacts of mainstream resevoir construction on downstream wildlife habitats.

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ABSTRACT

If a mainstream reservoir was constructed on the South Platte River in northeastern Colorado, downstream riparian wildlife would be severely impacted based on study of an analogous situation. Data collected above and downstream from John Martin Reservoir on the lower Arkansas River in southeastern Colorado identified changes occurring during 40 years since the dam was completed. Average downstream channel width was less ($P < 0.05$) than one-half that in upstream areas. The downstream channel profile had deepened ($P < 0.05$), and the vertical distance from river water level to the base of streamside trees was greater ($P < 0.05$) below the reservoir. The greatest decrease ($P < 0.03$) in stands of cottonwoods occurred below the reservoir where stands averaged only 5.4 ha/river mile compared to 16.8 ha/river mile upstream. Stream flow rates have been reduced and stabilized since dam construction with only 1 major flood in 1965. These factors, in combination with invasions of tamarisk (*Tamarix* spp.), have lowered groundwater in the streamside flood plain, nearly eliminated natural reproduction of plains cottonwoods (*Populus sargentii*), promoted sterile monocultures of perennial grasses, and reduced the food base of wild annual forbs essential to numerous wildlife species. Thus, both wildlife species richness and abundance have suffered. This same scenario would be expected with dam construction on the South Platte River. It is anticipated that invasions of tamarisk would not be a problem along the South Platte River because of winter temperatures, but opportunities for below-dam flooding would be lower. Water storage impoundments constructed away from the river would be less damaging to downstream riparian wildlife habitats than those placed across the main channel.

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Reproductive characteristics and habitat use of Rio Grande wild turkeys along the South Platte River, Colorado.

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ABSTRACT

Reproduction and habitat use by Rio Grande wild turkey (*meleagris gallopavo intemedia*) hens were studied in northeastern Colorado in 1986 and 1987. All adults (N=12) and 95% (N=20) of yearlings were known to attempt nesting. Adults initiated first nest attempts earlier than yearlings in 1987 but not in 1986. Adults and yearlings did not differ in clutch size or nesting success. There was an inverse relationship between clutch size and initiation date of first nests by adults. Clutch and egg size, however, were not related. Among yearlings, body mass at capture in February was positively correlated with subsequent nest-initiation date. Environmental and social stimuli, but not winter severity, are hypothesized proximate conditions regulating reproduction in this wild turkey population.

Nest habitat use varied. Thirty-three of 35 nests were in riparian habitats. Nests were either in western snowberry (*Symphoricarpos occidentalis*) (67%) or mixed forbs and grasses (33%). Early season nests were more likely to be in snowberry than late season nests. Nest sites were characterized by greater overstory canopy cover, more shrubs, fewer grasses, and greater understory cover and height than surrounding areas. These areas had more shrubs, fewer large trees, and greater understory cover and height than riparian habitats throughout the study area. Phenology of understory vegetation and the effect of such vegetation on nest predation may influence temporal patterns of nest habitat use.

Habitat use of 14 broods in riparian habitats also varied. Of 191 locations, 78% were within the riparian zone, 11% in agricultural uplands, and 11% on the edge between these habitats. Use of habitats was dependent on time of day. Within the riparian zone, older broods used grazed areas more often than young broods. Microhabitat use was examined at 35 brood and 29 random locations within the riparian zone. Plots used by young broods had higher frequencies of grasses than random plots.

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A review of recreational water quality criteria and an investigation into the recreational water quality of the South Platte River through the Denver metropolitan area.

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ABSTRACT

Due to the increased popularity of water-based recreational activities, the South Platte River through the Denver Metropolitan Area has become an important recreational resource. While improvements have been made to enhance the recreational use of the river, poor water quality currently reduces its recreation potential. Such water quality problems as poor aesthetics, obnoxious odors, and reduced clarity are prevalent and need to be corrected before the full recreational potential of the river can be realized.

A literature review of the historical development and current status of recreational water quality criteria indicated that aesthetics, bacteriological quality, chemical pollutants, clarity, dissolved oxygen, odor, pH, and temperature are the primary parameters of concern in recreational water quality. Using water quality data obtained from a 1985 USGS study, the existing recreational water quality of the river was compared with the criteria found in the literature for each of these parameters. The comparison revealed that the river suffers from elevated BOD5 and suspended solids concentrations, poor aesthetics and obnoxious odors.

Since the odors appeared to be organic in nature, it was hypothesized that the odors may be related to the elevated BOD5 concentrations. In other words, the BOD5 concentrations were promoting the growth of biological solids, which in turn were creating the odor problems. In order to substantiate this hypothesis, plug-flow biological reactor kinetics were used to develop a one-dimensional water quality model of the river. It was shown that the model could adequately predict the organic suspended solids concentrations form the BOD5 data. However, the correlation between the organic suspended solids concentrations and the odor problems still needs to be established.

If the relationship between organic suspended solids concentrations and the odor problems are verified, it should be possible to control the odor problems by setting appropriate BOD5 standards for the river. A methodology that allows such standards to be based on the allowable risk of a recreationist encountering an unacceptable level of odor is presented in the report. The methodology requires the use of odor evaluation techniques (to determine the probability of a recreationist experiencing a negative reaction to a given level of odor), water quality sampling 9 to determine the probability of a given level of odor occurring), and joint probability statistics (to combine the two probability functions).

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South Platte River Conference

SOUTH PLATTE RIVER RESOURCE MANAGEMENT: FINDING A BALANCE
November 13-14, 1990
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