Managing Flows for Multiple Purposes in Colorado:

Effects to Riparian Plant Communities

Barbara Galloway October 28, 2015

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Riparian Ecosystem

- A distinctive vegetation community that occurs in an environment adjacent to water. Without definitive boundaries, they may include stream banks, floodplains, wetlands, and sub-irrigated sites forming a transitional zone between upland and aquatic habitat. They depend on a high water table and are subject to periodic flooding and influence from the adjacent water body.

Riparian Communities in Colorado

- Very biologically diverse
- As much as 90% of Colorado's wildlife depend on riparian habitat
- Other functions and values of riparian areas:
  - Nutrient cycling
  - Transport of organic matter
  - Water quality improvements
  - Reduction of flood peaks
  - Bank stabilization and erosion reduction
  - Aquatic habitat improvements
  - Fishing, hunting, recreation

Colorado Water Plan

- Maintain, protect and restore riparian areas
- A statewide goal is to “support the development of multi-purpose projects and methods that benefit environmental and recreational water needs, as well as water needs for communities or agriculture”

Cottonwoods (*Populus* species) and the Water Table

- Most abundant native trees in riparian areas of western U.S.
- Require continually moist substrates for establishment
- Very sensitive to changes in ground water levels
- Seedlings require water tables within 1-2 m of surface
- Root growth allows young trees to survive gradual water table declines
- Mature trees typically found where depth to water table is ≤ 3.5 m, but observed where up to 7-9 m

Stream Flow and Cottonwood Growth

- Strong correlation between streamflow and tree growth in wide, unconfined valleys where alluvial ground water typically fluctuates directly with surface water (e.g. Colorado River in the Grand Valley)
  - Maximum tree growth in years with highest annual flows
- In narrow mountain canyons, relation between tree growth and streamflow is weaker and more variable (e.g. Little Cimarron River)

Hydrologic Variables Affecting Cottonwood Reproduction and Survival

- Annual stream flow volumes
- Shorter term variations in total amount of water available in a riparian zone
- Temporal distribution (seasonal and annual) of water, particularly flood frequency
- Rate of flood water recession
- Duration of water inundation (anaerobic conditions)

Fluvial Processes Affecting Cottonwoods

- Cottonwoods are adapted to the temporal and spatial variability of fluvial processes
- High flows erode, transport and deposit sediment that creates nursery sites suitable for cottonwood establishment
- Floods
  - create openings in dense riparian growth
  - transport seeds
  - saturate floodplains to encourage seedling growth
  - deposit nutrient-rich sediments
- Establishment of cottonwood seedlings is largely restricted to bare, moist, unshaded sites created by channel movement and flood deposition (i.e. a dynamic stream channel)
- Age and distribution of cottonwood stands are closely associated with patterns of channel movement and floodplain building processes

Changes in a Watershed

- Effects to a riparian area may be due to disturbances within any part of the watershed, including upland areas (such as land use changes)
- Flow regulation and channel stabilization alter natural stream channel dynamics and natural vegetation dynamics of the associated riparian corridor


Google earth

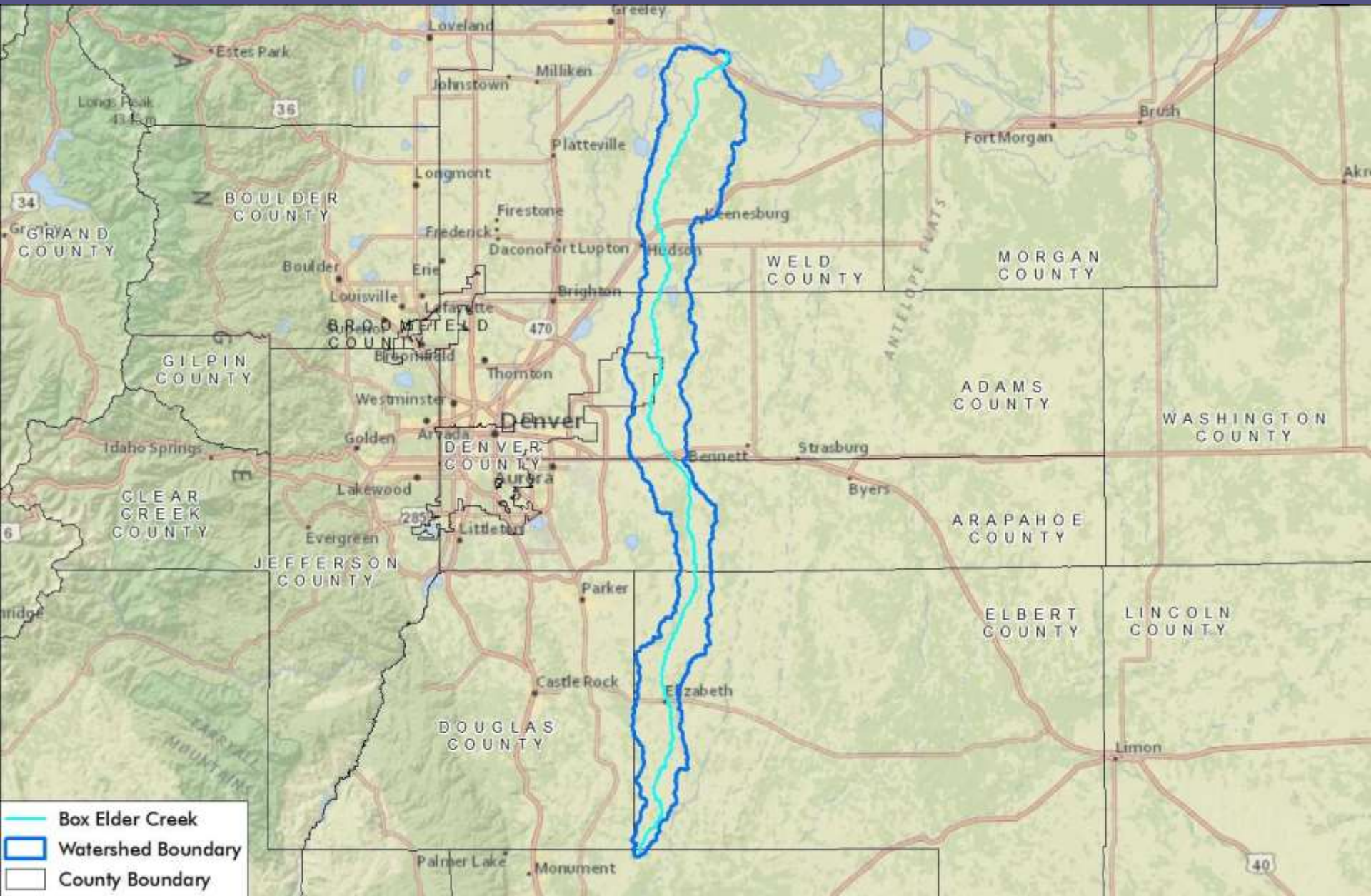
Physiological Responses of Cottonwoods to Drought Stress due to Reduced Water Availability

- Within weeks:
  - Reduced shoot growth
  - Reduced leaf area
  - Reduced trunk expansion
  - Reduced seed production
  - Seedling mortality
  - Leaf senescence and mortality
  - Branch sacrifice (often seen in dry climates)
- Within multiple seasons:
  - Crown die-back
  - Tree mortality

Coal Creek USGS Plains Cottonwood Study

- 4- year study in South Lowry Range of *Populus deltoides* ssp *monilifera*
- Study of effects to alluvial water table due to mining of the alluvium, which caused water table decline
- Sustained declines ≥ 1 m produced
  - Leaf desiccation and branch dieback in 3 weeks
  - Large declines in live crown volume, stem growth, and 88% mortality over 3-year period
- Gradual declines ~ 0.5 m had no measurable effect on mortality, stem growth or live crown volume, only declines in annual branch growth
- Plant-available water content of coarse soils is typically 3-4 times less than that of finer textured soils
- Similar effects could also occur due to channel incision, surface water diversion, dam construction, or ground water pumping
- Efforts to minimize loss of riparian cottonwoods "requires an understanding of the role of surface and ground water dynamics in the establishment of new, and maintenance of existing stands."

Box Elder Creek Watershed



Box Elder Creek

- Application to withdraw 500 AF/yr at up to 1,000 gpm from 80-foot alluvial well near Watkins for oil and gas development. Water would be fully consumed
- Protestors of the application concerns:
  - Further reduction in creek flow which is already often dry
  - Loss of riparian vegetation and wetlands
- Office of the State Engineer approved a 1-year Substitute Water Supply Plan in 2014, so pumping can begin


PRIVATE PROPERTY
ESPASSING

Box Elder Creek

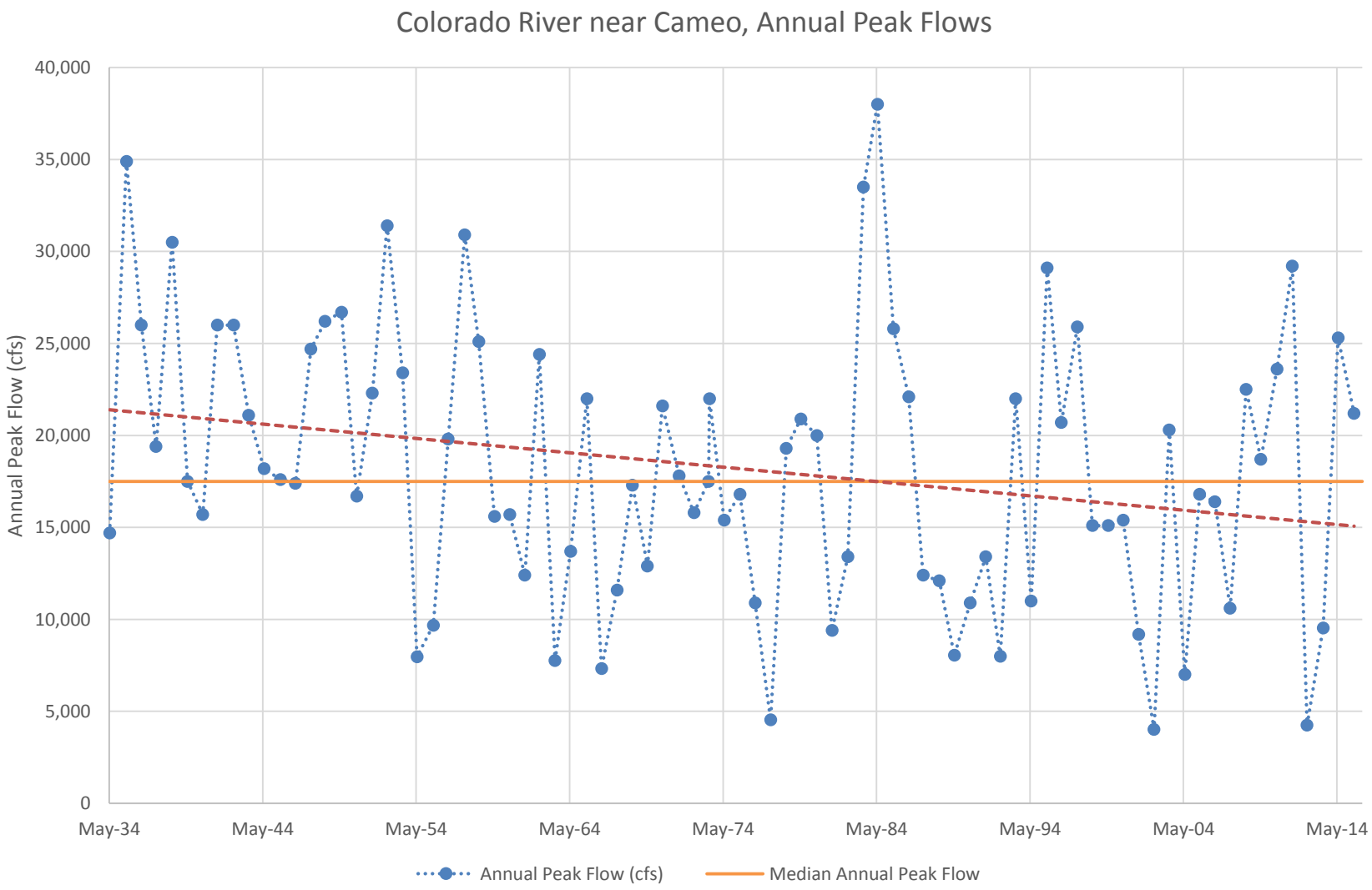
- Seven existing alluvial wells have rights to pump 4,995 AF/yr of alluvial ground water in same section as the newly approved alluvial well.
- USGS estimated average rate of underflow through alluvium near Watkins of 2,100 AF/yr.
- When pumping rate exceeds the recharge rate to the alluvium, the alluvial ground water level will decline and surface flow, which already occurs infrequently at Watkins, will occur even less often.

Little Cimarron River

- In the first permanent water-sharing agreement of its kind in Colorado, an innovative arrangement has been struck to leave water in the Little Cimarron River in late summer instead of using it for agriculture (foregoing a 2nd or 3rd hay crop)
- Up to five cubic feet per second of water that was traditionally diverted from the Little Cimarron River will now be left in the river starting in mid-summer when stream flows drop, preventing the river from going dry
- Much of the river is managed as a wild trout stream by Colorado Parks and Wildlife

Little Cimarron River

- Agreement may not significantly benefit riparian vegetation along the stream, which appear to be supported by numerous springs, as well as irrigation ditches above the river on both slopes, resulting in a high ground water table that keeps roots saturated even when the stream is dry


Colorado River near Cameo, Annual Peak Flows
Annual Peak Flow (cfs)
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
May-34
May-44
May-54
May-64
May-74
May-84
May-94
May-04
May-14
Annual Peak Flow (cfs)
Median Annual Peak Flow

Colorado River at Palisade: reproduction of seedlings due to high flow in 2011

Colorado River at Palisade


USGS 09106150 Colorado River gage
Google earth
N
700 ft

Grand Valley Water Table

- The Grand Valley Drainage District maintains 260 miles of drains to lower the ground water table
- Drains carry over a billion gallons of water (3,000 acre-feet) each day of irrigation return flows back to the Colorado River
- Shallow ground water is not being pumped for use because it is saline as a result of irrigation water percolation and from the underlying Mancos shale

Cottonwoods on the Colorado River in the Grand Valley

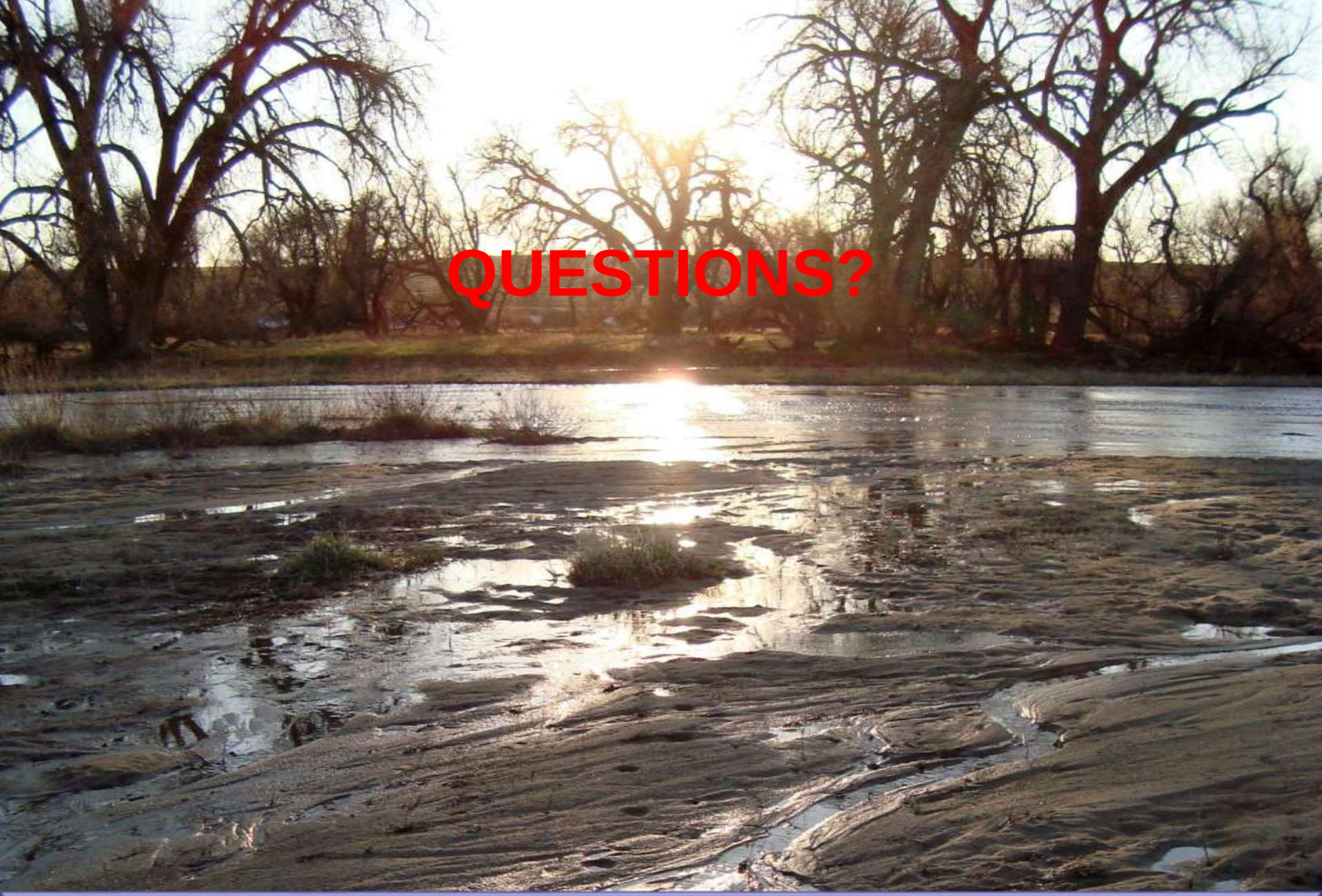
- Less tree growth due to overall reduced annual flow
- Less seedling recruitment due to reduced flood flows
- Irrigation return flows support cottonwood growth
- High, stable ground water table should maintain the existing riparian corridor

Conclusions and Recommendations

- Effective management of streams to promote or maintain native riparian vegetation requires an understanding of locally dominant fluvial geomorphic processes, historic hydrology, and climate variation (need site-specific information)
- Also need to identify hydrologic thresholds for maintaining cottonwoods (and other riparian vegetation) by monitoring stream flow permanence, ground water depth, and ground water level fluctuation
- "Riparian restoration requires the integrated management of both the land and water, creating complexities in both biological and physical resources and complicating [stream] administration …"

Complications to Achieving the Goal of Protecting Riparian Areas

- Already heavy water use has resulted in unnatural hydrologic conditions in many Colorado streams
- Volume of surface or ground water in a stream channel depends on runoff, recharge to ground water, diversions, and evapotranspiration, all of which can change over short time periods
- Difficult to predict when and to what extent recharge to an alluvial aquifer will occur, and how far downstream such recharge will reach
- Climate change likely will further change the volume and timing of stream hydrology and water availability
- Uncertainty in climate projections is especially high with regard to extreme events that drive riparian fluvial dynamics



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