Historical Changes to Culturally-Important Riparian Plants along the Colorado River:

a progress report on a pilot study integrating science and traditional ecological knowledge

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Outline

- Introduction
  - Overview of project need and objectives
  - GCDAMP goals and Desired Future Conditions
  - Drivers of vegetation change
- Project summary
  - Literature compilation
  - Photo matching
  - Analysis
- Next steps and future applications

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Why this study?

- Plants have cultural value –- as habitat (for insects, animals, humans), as food, traditional medicine, source of biodiversity, etc. (Values are culturally-determined!)

- Dam operations change riparian plant communities by altering the hydrology, nutrient supply, sediment supply, and disturbance regime of the natural system

- Many existing studies discuss effects of dams on vegetation but few examine effects to culturally-important plants (or to TCPs and cultural landscapes)

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Why this study? (continued):

- Cultural values influence why we care about plants and also why and how we study plants
- GCMRC vegetation monitoring data driven primarily by biology science questions, not cultural concerns
- Tribal ethnobotanical inventories and veg monitoring data not well integrated with other GCDAMP studies
- Need for baseline information to inform future vegetation management and restoration activities

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AMP Goals, INs and SSQs

- AMP Goal 6: Protect or improve the biotic riparian and spring communities, including T&E species and their habitats
- CMINs 6.1.1, 6.2.1., 6.5.1, 6.6.1: Determine and track the abundance, composition, distribution and area of terrestrial native and non-native vegetation species in the CRE.

- SSQ 2-1: Do dam-controlled flows affect (increase or decrease rates of erosion and vegetation growth at archaeological sites and TCP sites, and if so, how?
- SSQ 2-2: How do flows impact old high water zone terraces in the CRE . . . ?
- SSQ 2-7: Are dam-controlled flows affecting TCPs and other tribally-valued resources in the CRE, and if so, in what respects are they being affected, and are those effects considered positive or negative by the tribes who value these resources?

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8+ Desired Future Conditions

- GCDAMP stakeholders have expressed desire for:
  - Native riparian systems that are diverse, healthy, productive, self sustaining, and ecologically appropriate
  - Native, self-sustaining riverine wetlands
  - Riparian vegetation and habitat with appropriate mix of ages
  - Habitat for sensitive species
  - Habitat for neotropical migratory birds, waterfowl, native birds
  - Healthy, self-sustaining populations of native riparian fauna (both resident and migratory)
  - A river corridor landscape that matches natural conditions as closely as possible
  - Attributes of Traditional Cultural Properties and their culturally appropriate conditions are maintained

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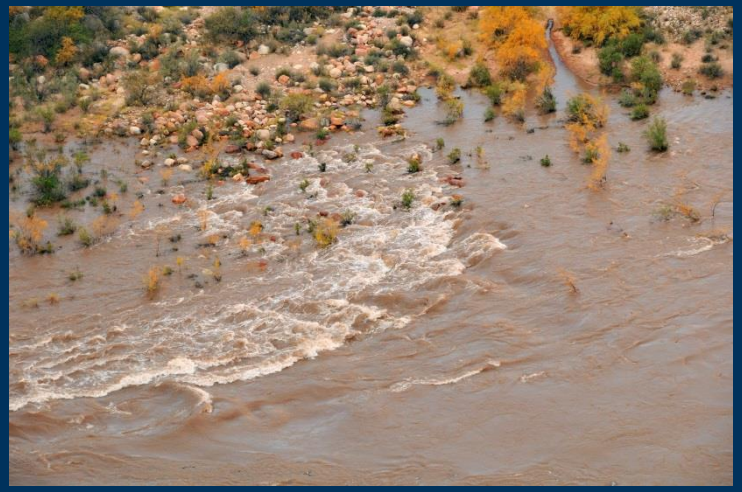
Drivers of vegetation change

- Regional climate change (e.g., drought, killing frosts)
- Specific weather events (e.g., debris flows) →
- Diseases, pathogens
- Non-native invasions
- Direct human impacts (e.g., trampling, selective removal)
- Human alteration of natural disturbance regime (e.g., fire, grazing, dam operations)



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Drivers of Riparian Vegetation Change

- Hydrology Dominates!
  - Volume of flow
  - Variability of flows
  - Seasonality of high flows
  - Seasonality of low flows
  - Floods (presence/absence/size/duration)
  - Location and type of sediment deposited by flows
- Nutrients in water & fluvial deposits
- Other interacting factors (invasive species, pests, human activities, etc.) secondary

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Original Project Goals:

Link TEK (ethnobotany) with western science to answer the following questions:

- Question 1: How have attributes* of culturally-valued riparian plants changed since closure of Glen Canyon Dam?
  - Abundance, distribution, density, diversity, size


Photograph by E. Palmquist

- Question 2: Have changes in the abundance and distribution of culturally-valued plants affected TCPs / cultural values important to GCDAMP Tribes? If so, how?


Photograph by M. Yeatts

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Pilot Study Focal Species

- Goodding willow (*Salix gooddingii)*
- Cottonwood (*Populus fremonti*)
- Netleaf Hackberry (*Celtis reticulata)*
- Honey Mesquite (*Prosopis glandulosa*)
- Coyote willow (*Salix exigua*)
- Seep willow (*Baccharis emoryi, B.salicifolia*)
- Apache plume (*Fallugia paradoxa*)
- Arrow weed (*Pluchea sericea*)
- Common reed (*Phragmites australis)*
- Cattail (*Typha sp*.)
- Horsetail (*Equisetum sp*.)
- Dropseed (*Sporobolus* sp.)
- Indian Rice Grass (*Achnatherum hymenoids*)

Trees

Shrubs

Grasses & Grass-like Plants

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- Also Prince's plume (Stanleya pinnata), Globemallow (Sphaeralcea ambigua), and Canyon Grape (Vitis arizonica)

Methods

- **Part 1: Compile data from multiple sources:**
  - **Match and analyze historical photos**
  - **Compile and analyze published literature**
  - **Compile unpublished monitoring data**

- **Part 2: Engage tribal members to elicit perspectives about significance of changes**
  - **Structured interviews**
  - **Unstructured interviews**
  - **Choice experiments**

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Sources of Information

- Published articles and reports (botanical, archaeological, etc.)
- Vegetation monitoring data
- Historical photography and recent photo matches (Stanton-1889/90, Birdseye-1923, Webb- 1990s-2010s)
- Historical journals (Clover, Nevills, etc.)
- Oral traditions

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Published literature

- Scientific literature is extensive, varies by species. For example:
  - hundreds of articles / books about Cottonwoods
  - rapidly increasing literature about Phragmites sp.
  - virtually no literature about arrowweed life history

- Ethnobotanical literature extensive but uneven

- Final bibliography focused on information important for restoration of native riparian species

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Example: Shafroth et al. 2010
"Ecosystem Effects of Environmental Flows"

- Cottonwood (*Populus fremonti*) and Goodding Willow seed dispersal needs to be coincident with spring floods for successful propagation

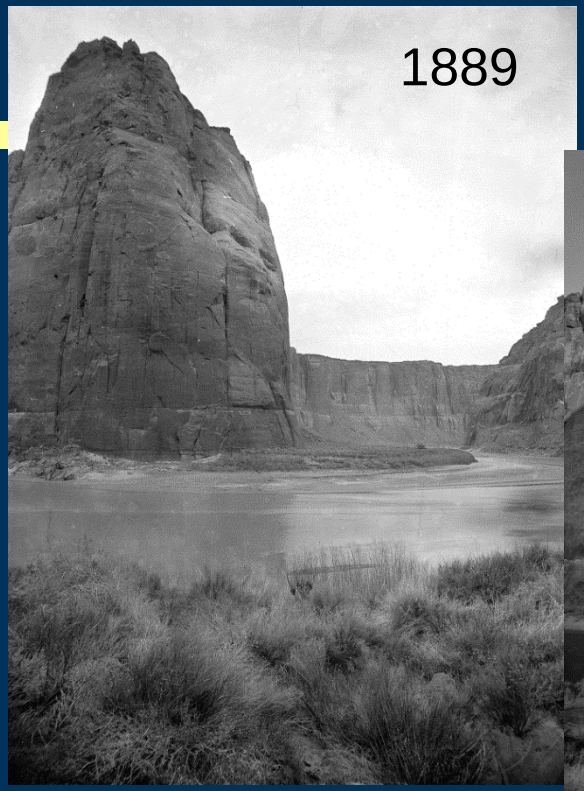
- Propagation benefits from gradual flood recession (≤ 6 cm/day for Populus; <4cm/day for Salix)

- Susceptibility to flood impacts differ: *Salix* and *Populus* seedlings more resilient to scour and burial than *Tamarix*

- *Tamarix, Populus, Salix* seed dispersal timing overlaps, but is not identical – timing of flows matter!

Shafroth, P.S. and 8 others, 2010, Ecosystem effects of environmental flows: modelling and experimental in a dryland river. *Fresh Water Biology* 55, 68-85.

Photo Matching & Analysis Component



Photograph by F.A. Nims, Dec. 23, 1889

Photograph by T. Melis, Feb. 10, 1992

Photograph by B. Lemke, April 21, 2011

Glen Canyon, RM -10.3

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Photo Matching

1. Relocate historical view
2. Relocate exact position of original photographer
3. Replicate the view
4. Compare identical views at different time periods
5. Record plant differences between the images
6. Document differences across multiple images
7. Summarize changes throughout river corridor

Top Image: RB Stanton, 1890
Bottom Image: RH Webb, 1990

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Limitations of historical image matching

- quality of imagery
- ability to identify species
- seasonal differences
- representativeness
- obtaining high-quality photo matches requires large time investment
- methods for quantifying change difficult to apply (except for large distinctive species, e.g., barrel cactus)

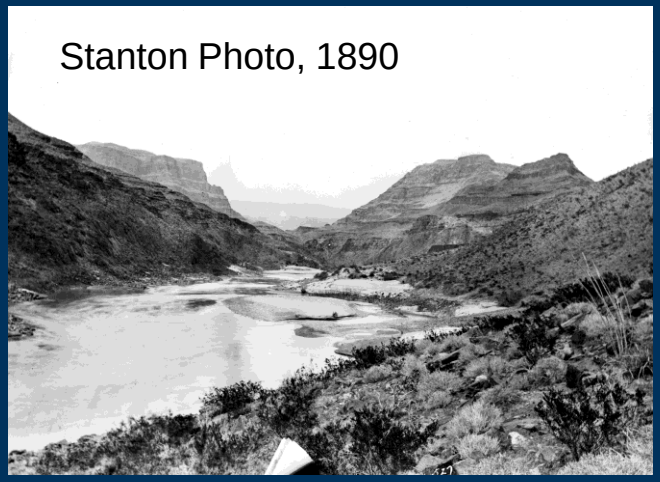

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Photo Analysis

Scott M.L., Webb R.H., Johnson R.R., Turner R.M., Friedman J.M., and Fairley H.C. *In review*. Evaluating Riparian Vegetation Change in Canyon-bound Reaches of the Colorado River Using Spatially Extensive Matched Photo Sets. Chapter 10. *In:* Johnson R.R., Carothers S.W., Finch, D.M., Kingsley, K.J.,and Stanley, J.T. (editors) 20XX. *Riparian Research and Management: Past, Present, Future.* Gen. Tech. Rep. RMRS-GTR-XXXX. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station

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Results of sample analysis, 1990-2012

- Woody vegetation (.e.g., tamarisk, baccharis) increased throughout river corridor, 1990-2012
- 89% of analyzed photo matches showed increases in tamarisk
- 53% showed increases in *Baccharis sp.*
- 2% showed clear increases in *Salix exigua*
- 9% showed no significant change
- <2% showed a decrease
- Less change in narrow canyon-bound reaches

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Analysis Results, continued

- **Most vegetation increase is below 45K cfs**
- **Above 45K, some vegetation changes are due to encroachment of OHWZ and desert species (e.g., mesquite, acacia, cactus)**
- **Some die-back of OHWZ mesquite canopy**
- **Some changes due to human intervention (e.g., Russian olive removal, experimental planting mesquite in NHWZ) – need systematic documentation!**

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Preliminary data – do not cite

Soap Creek, RM 11.5

Photograph by E.C. LaRue, August 02,1923

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Photograph by A.H. Fairley, April 29, 2017

Rattlesnake Camp, RM 74.5

Photograph by E.C. LaRue, August 15,1923

Photograph by A.H Fairley, May 3, 2017

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Fossil Canyon, RM 124.8

Photograph by E.C. LaRue, September 6,1923

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Photograph by A.H Fairley, May 8, 2017

Photograph by E.C. LaRue, September 6,1923

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Photograph by A.H Fairley, May 10, 2017


National Canyon, RM 166.9
288
Photograph by E.C. LaRue, September 16,1923


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Photograph by A.H Fairley, May 11, 2017

Stairway, RM 171.5

Photograph by E.C. LaRue, September 17,1923

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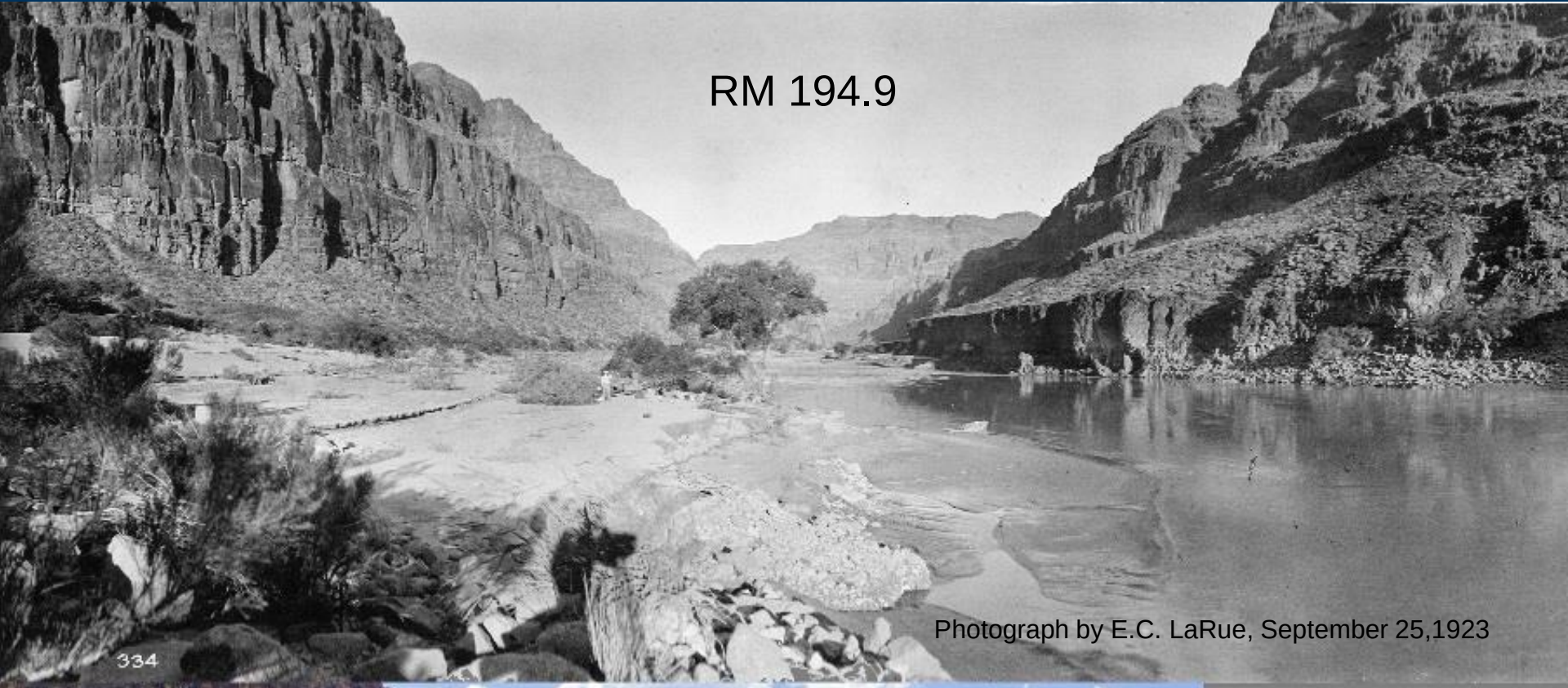
Photograph by A.H Fairley, May 11, 2017

RM 194.9



Photograph by E.C. LaRue, September 25,1923

Photograph by A.H Fairley, May 11, 2017

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RM 197.0
336
Photograph by E.C. LaRue, September 25,1923


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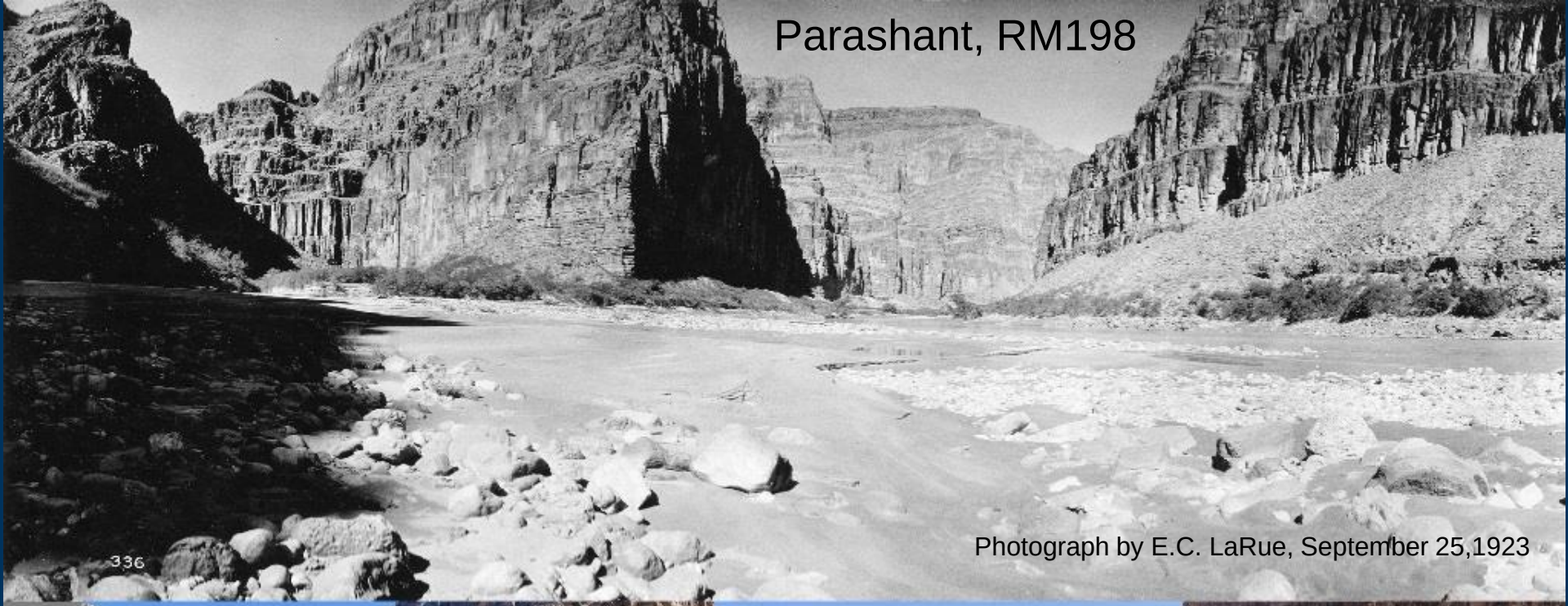
science for a changing world
Photograph by A.H Fairley, May 11, 2017

Parashant, RM198



Photograph by E.C. LaRue, September 25,1923

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Photograph by A.H Fairley, May 12, 2017

Granite Park, RM 209.1

Photograph by E.C. LaRue, September 28,1923

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Photograph by A.H Fairley, May 14, 2017

RM 222.3

Photograph by E.C. LaRue, October 1,1923

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Photograph by A.H Fairley, May 14, 2017

Next steps & future applications

- **Next steps (FY2017):**
  - Continue matching 1923 images
  - Continue archival research
  - Complete analysis of matched photos
  - Finish compiling bibliography

- **Future applications of results:**
  - Photo matches provide visual baseline for future comparisons of vegetation change
  - Bibliography will help guide and inform future restoration efforts

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Elicit Stakeholder Perspectives re: riparian restoration objectives?

Possible methods:

- Choice experiments using photo comparisons
  - "Which of paired photos do you prefer and why?"
- Semi-structured interviews
- Structured "opinion surveys"
- Focus group discussions
- Other methods?

Photograph by M. Yeatts

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Questions?
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