

# MEADOW RESTORATION ON NATIONAL FORESTS IN CALIFORNIA : A headwaters approach to water- resources protection during climatic change



# WATER-RESOURCE CHALLENGES RELATED TO CLIMATE CHANGE:

- Rain will replace snow at mid-elevations in Sierra
- Larger and more frequent floods
- Decreased duration and volume of base flows
- Increased water temperature
- Increased sediment loads



# FOREST MANAGEMENT ACTIVITIES WITH POTENTIAL TO IMPROVE WATER RESOURCES IN RESPONSE TO CLIMATE CHANGE

- Vegetation management
- Fire/fuels management
- Road drainage improvements
- Groundwater storage → meadow restoration

# HOW DO MEADOWS AFFECT HYDROLOGIC PROCESSES?

- High flows spread across meadows
- Sediment retained on meadow surfaces
- Alluvial meadow aquifers store runoff
- Meadow plants use stored groundwater
- Slow release of cool, clean water during summer



# MEADOWS ON NATIONAL FORESTS IN THE SIERRA NEVADA

- 11,700 meadows within NF boundaries
- 222,000 acres including inholdings
- Roughly another 100,000 acres outside NFs
- Located on streams important for water supply



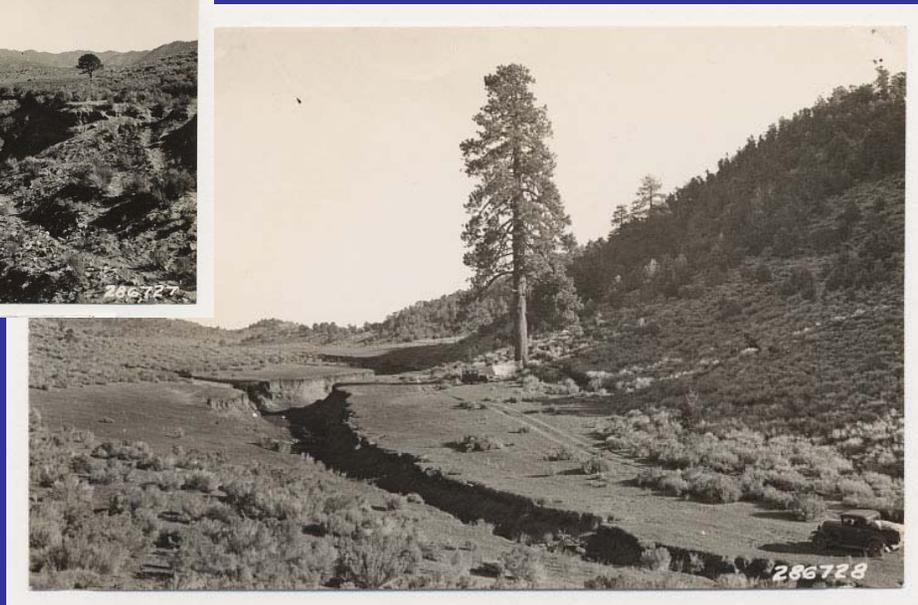
# HISTORICAL LAND USES

- Unrestricted grazing from 1860's to 90's
- Road and railroad construction for logging, mining
- Managed livestock and pack stock grazing continues
- Current USFS guidelines provide protection for meadows



# MEADOW EROSION

- Gullies have eroded many meadows throughout the Sierra
- Erosion linked to historical land uses
- Climate change and intrinsic thresholds may be factors



# EFFECTS OF EROSION

- Floods move quickly through incised gully channels
- Groundwater drains rapidly to gullies
- Streamflow changes from perennial to intermittent
- Meadow vegetation is replaced with woody shrubs, conifers
- Bank erosion accelerates when meadow sod is lost
- Sediment loads increase
- Fish and wildlife habitat threatened

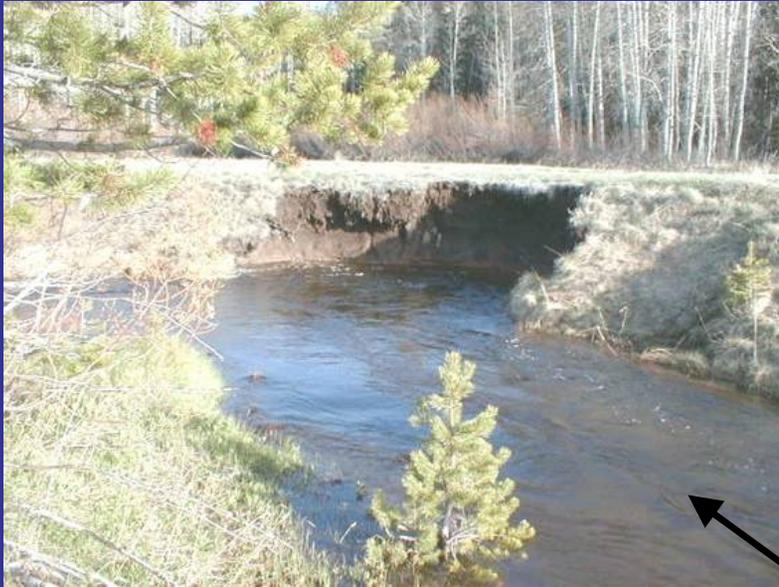


# MEADOW RESTORATION ON NATIONAL FORESTS

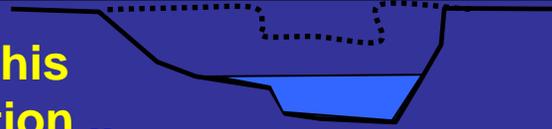
- USFS restoration began ca. 1940 using check dams
- “Plug and pond” is now commonly used
- Rate of progress controlled by funding



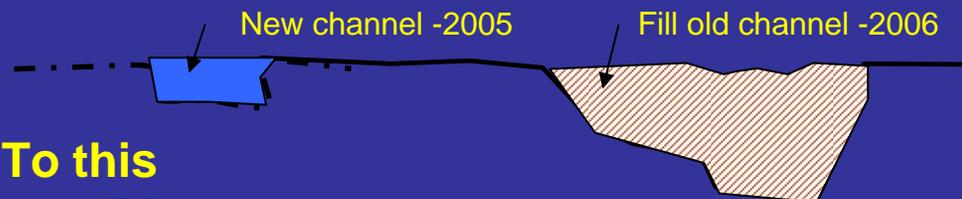
# HYDROLOGIC EFFECTS OF MEADOW "PLUG AND POND" RESTORATION



**From this Condition ..**  
**Old channel (2000) at 45 CFS**



**To this condition...**  
**New channel (2007) at ~ 20-25 CFS**



# POTENTIAL WATER STORAGE IN SIERRAN MEADOWS

- Storage = meadow area x gully depth x specific yield
- Restoration benefits could range from 50,000 to 500,000 ac-ft annually
- Additional data collection needed to refine estimates



# RECENT RESEARCH

- Studies completed or in progress at UCD, CSUS, Stanford, others
- Results support potential for groundwater storage and flood attenuation
- Higher evapotranspiration after restoration
- Mixed results on baseflow regimen

# RESTORATION COSTS

- Roughly \$100 to \$250 per acre-foot over 10 years based on recent projects
- Little or no long-term maintenance costs
- Limited risk of failure

# MAJOR QUESTIONS REMAINING

- Regional potential for groundwater storage
- Hillslope/meadow hydrologic relations
- Sediment budgets and erosion processes
- Effects on baseflow regimen
- Water rights



# PLANNED ACTIVITIES

- San Joaquin watershed study begins this year
- Proposal for regional survey submitted to NFWF
- New plug&pond project on Tahoe NF

# OUTLOOK

- California has a critical need for additional high-quality water
- Meadow restoration can be a part of the solution
- USFS is interested in developing partners to expand and accelerate restoration efforts



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