SIERRA NEVADA MEADOW HYDROLOGY ASSESSMENT

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Pacific Southwest Region
DWR State Water Plan
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SIERRA NEVADA NATIONAL FOREST MEADOW HYDROLOGIC ASSESSMENT

- Objectives: Estimate the amount of restored groundwater that could support summer streamflow on National Forest lands in the Sierra Nevada and provide an approach to selecting and prioritizing projects based on benefits
- Funding: NFWF, DWR
- Partners: UC Merced, UC Davis, USGS, UNR
- Geographic Scope: 10 Sierra Nevada National Forests
- Timeline: June 2010 to March 2014

APPROACH

- TASK 1—Synthesize existing information (USFS)
- TASK 2—Delineate meadows on national forests and develop sample pool (USFS)
- TASK 3—Field check meadow locations and areas (UCD)
- TASK 4—Assess extent of meadow erosion (UCD)
- TASK 5—Monitor selected meadows and develop water budgets and groundwater models (UCM, USGS, UNR)
- TASK 6—Summarize results in final report (USFS)

Task 1: Results of previous studies of meadow restoration effects on summer streamflow in the Western U.S.

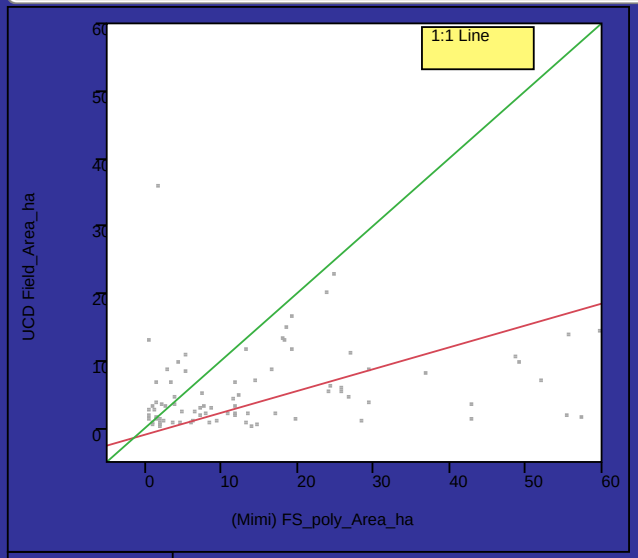
Result	Number of studies
Increased summer baseflow volume	4
Reduced summer baseflow volume	0
Increased summer flow duration/extent	5
Reduced summer flow duration/extent	1

Task 2—Delineate meadows

- Topographic slope < 6% (USGS 30 m DEM)
- Within 50 m of NHD streamline
- Partial cover of herbaceous/shrub vegetation (CALVEG)
- Landsat 5 Thematic Mapper data
- Total of 26,000 meadows, 615,000 acres
- Previous SNFPA estimate 220,000 acres
- new UCD estimate of 191,000 acres

Task 3—Field check meadow areas (UCD)

Bivariate Fit of Field_Area_ha By FS_poly_Area_ha



Linear Fit

Field_Area_ha = -0.963783 + 0.3237821*FS_poly_Area_ha

Summary of Fit

RSquare	0.69279
RSquare Adj	0.689749
Root Mean Square Error	13.48544
Mean of Response	10.55893
Observations (or Sum Wgts)	103

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Ratio
Model	1	41420.804	41420.8	227.7656
Error	101	18367.572	181.9	Prob > F
C. Total	102	59788.376		<.0001

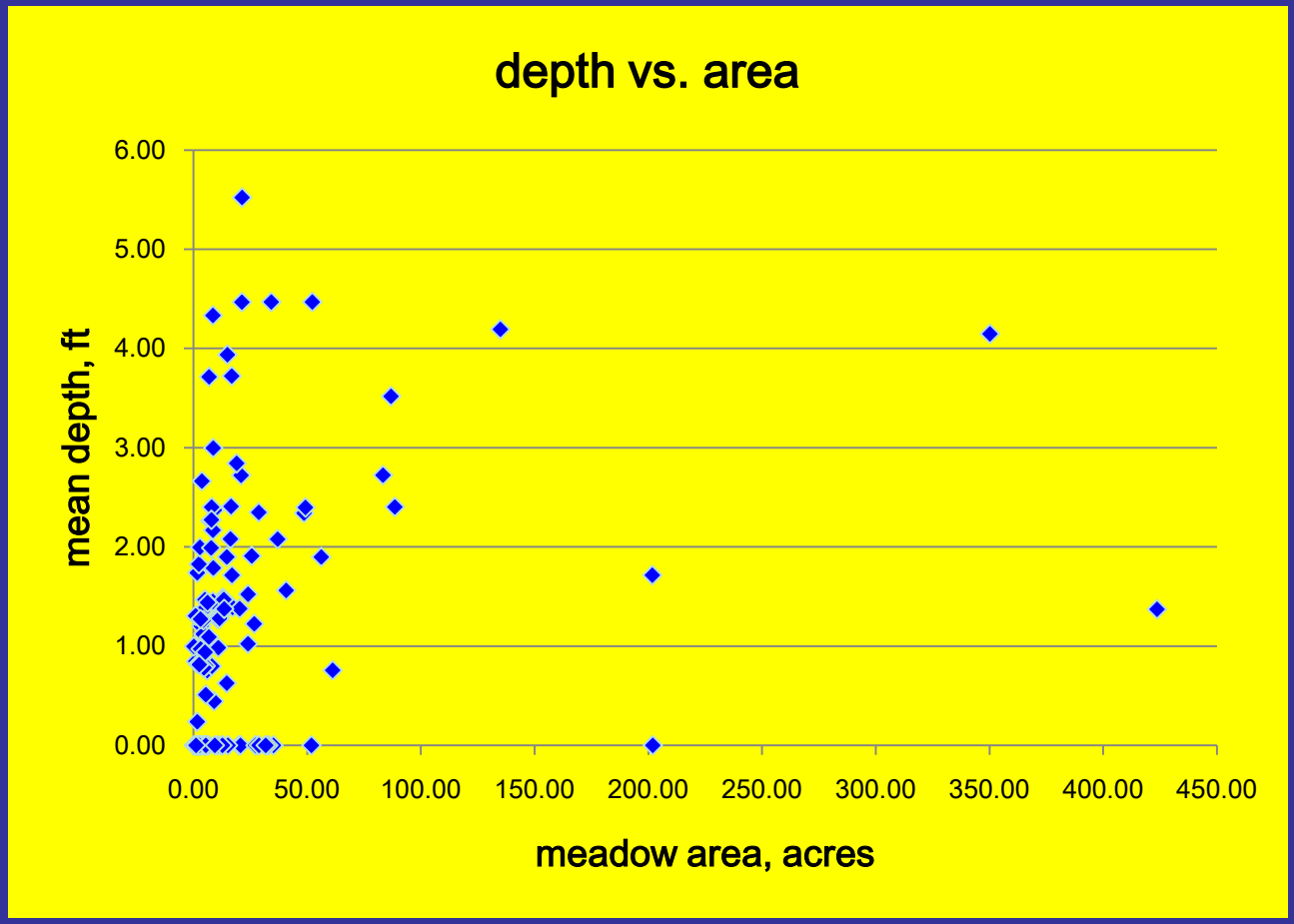
Parameter Estimates

Term	Estimate	Std Error	t Ratio	Prob>|t|
Intercept	-0.963783	1.532495	-0.63	0.5308
FS_poly_Area_ha	0.3237821	0.021454	15.09	<.0001

Task 4—Assess extent of meadow erosion (UCD)

Forest	Mean depth (ft)	Max depth (ft)
ENF	2.1	8.3
INF	2.1	7.9
LNF	2.0	12.6
MDF	1.7	6.6
PNF	1.7	8.3
SNF	1.6	7.7
SQF	1.6	6.1
STF	1.8	9.2
TMU	2.8	6.5
TNF	2.7	10.1
Mean	2.0	8.3

Task 4—meadow depth vs. area

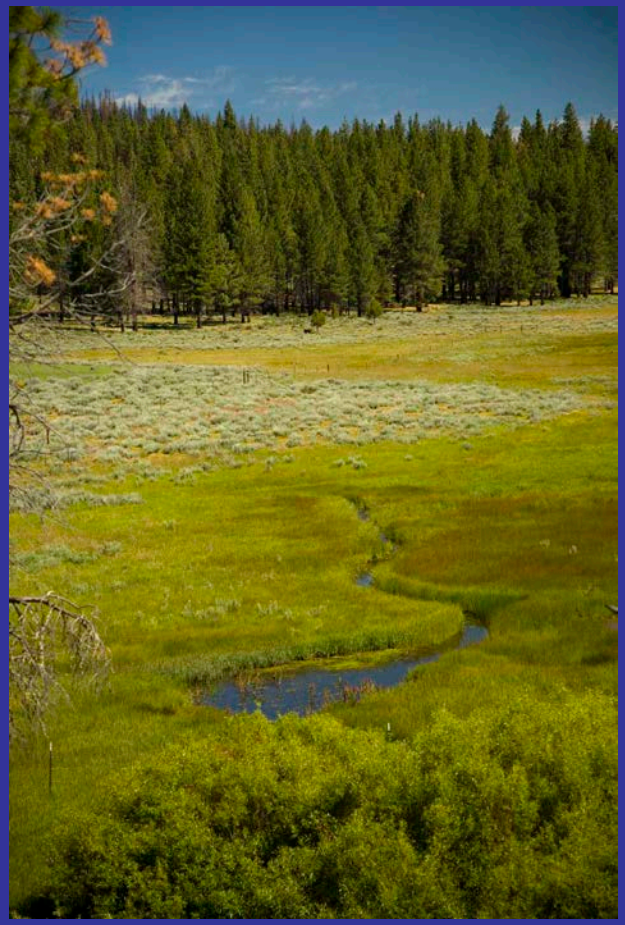


Task 4—Potential improvement in groundwater storage (rough estimates)

- Area of 190,000 meadow acres
- About 50% eroded → 95,000 acres
- Erosion depth about 4 ft
- Specific yield estimated at 0.2
- > capacity = 95,000 acres x 4 ft x 0.2 = 76,000 acre-ft
- Need to adjust for ET

Task 5—Water balances (UCM)

- Water balances indicate depletion of groundwater storage in meadow aquifers supplies summer streamflow in eroded meadows.
- ET may not decline as much in eroded meadows as expected.
- Restored and eroded meadows are supplied by groundwater from surrounding bedrock.
- Additional field work in 2013.

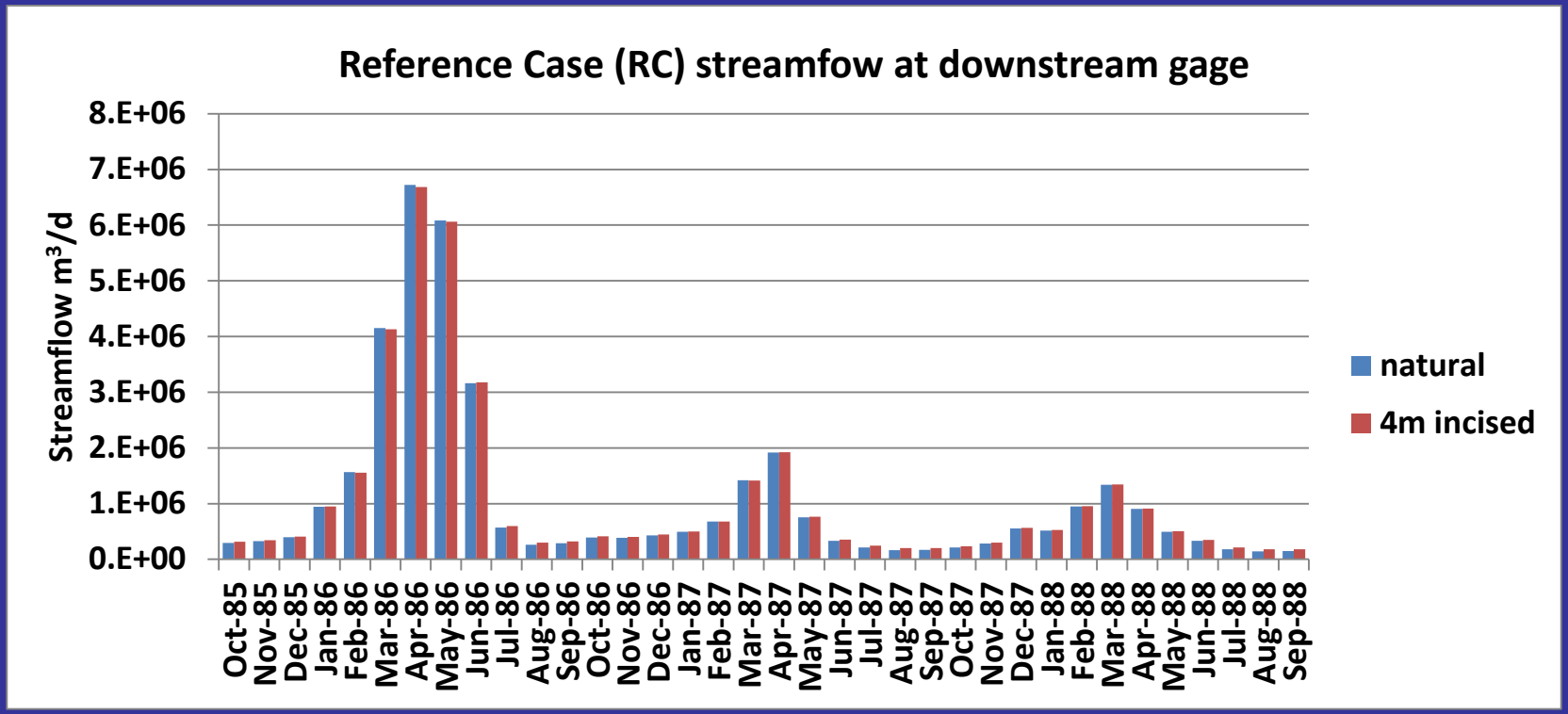


Task 5—Pond and plug hydrology (UNR)

- Most ponds have water surfaces higher than surrounding meadow water tables.
- These ponds function as groundwater recharge areas.
- In contast, a few ponds are groundwater “drains”.

Task 5—USGS groundwater modeling, Sagehen watershed, 1985-88

- Streamflow is higher during early summer recession under natural (uneroded) conditions
- Eroded meadows support higher late-summer flows
- ET is higher in natural uneroded meadows
- Initial depletion of GW storage in eroded meadows exceeds ET “savings”
- Long-term effects yet to be determined
- Tributary streams lose perennial flow to erosion


Reference Case (RC) streamfow at downstream gage
Streamflow m³/d
8.E+06
7.E+06
6.E+06
5.E+06
4.E+06
3.E+06
2.E+06
1.E+06
0.E+00
Oct-85
Nov-85
Dec-85
Jan-86
Feb-86
Mar-86
Apr-86
May-86
Jun-86
Jul-86
Aug-86
Sep-86
Oct-86
Nov-86
Dec-86
Jan-87
Feb-87
Mar-87
Apr-87
May-87
Jun-87
Jul-87
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Sep-87
Oct-87
Nov-87
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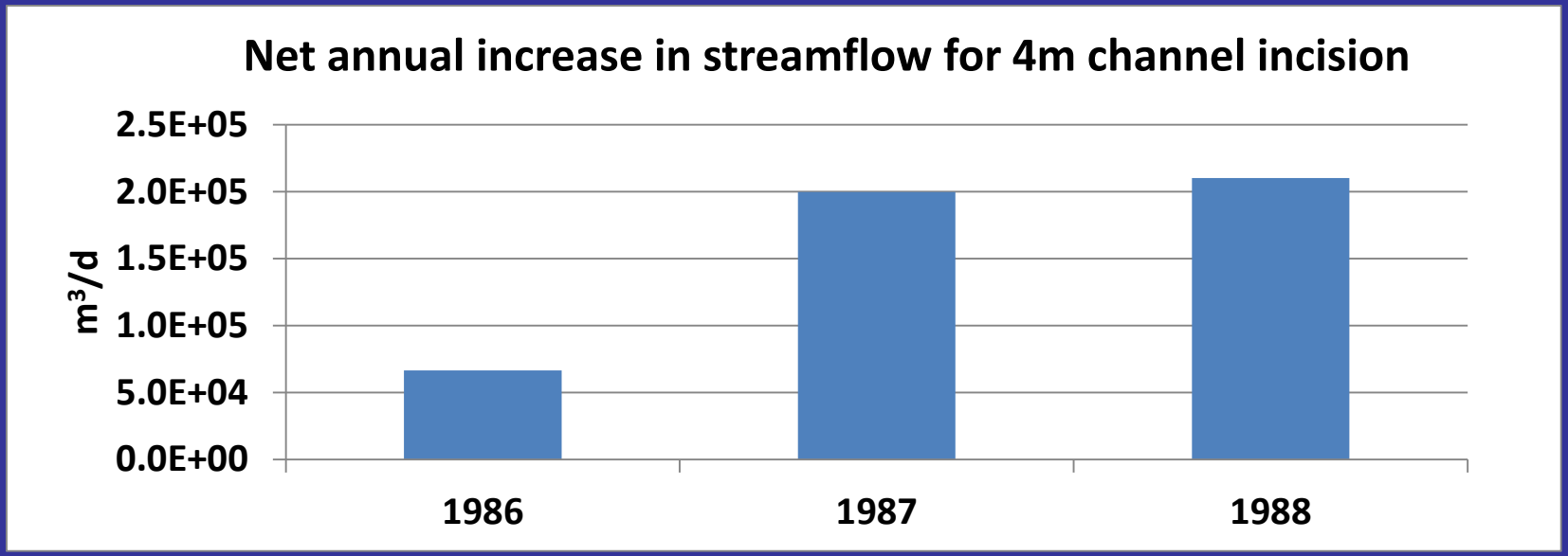
Aug-88
Sep-88
natural
4m incised


Net annual increase in streamflow for 4m channel incision
m³/d
2.5E+05
2.0E+05
1.5E+05
1.0E+05
5.0E+04
0.0E+00
1986
1987
1988

Task 6—Final report

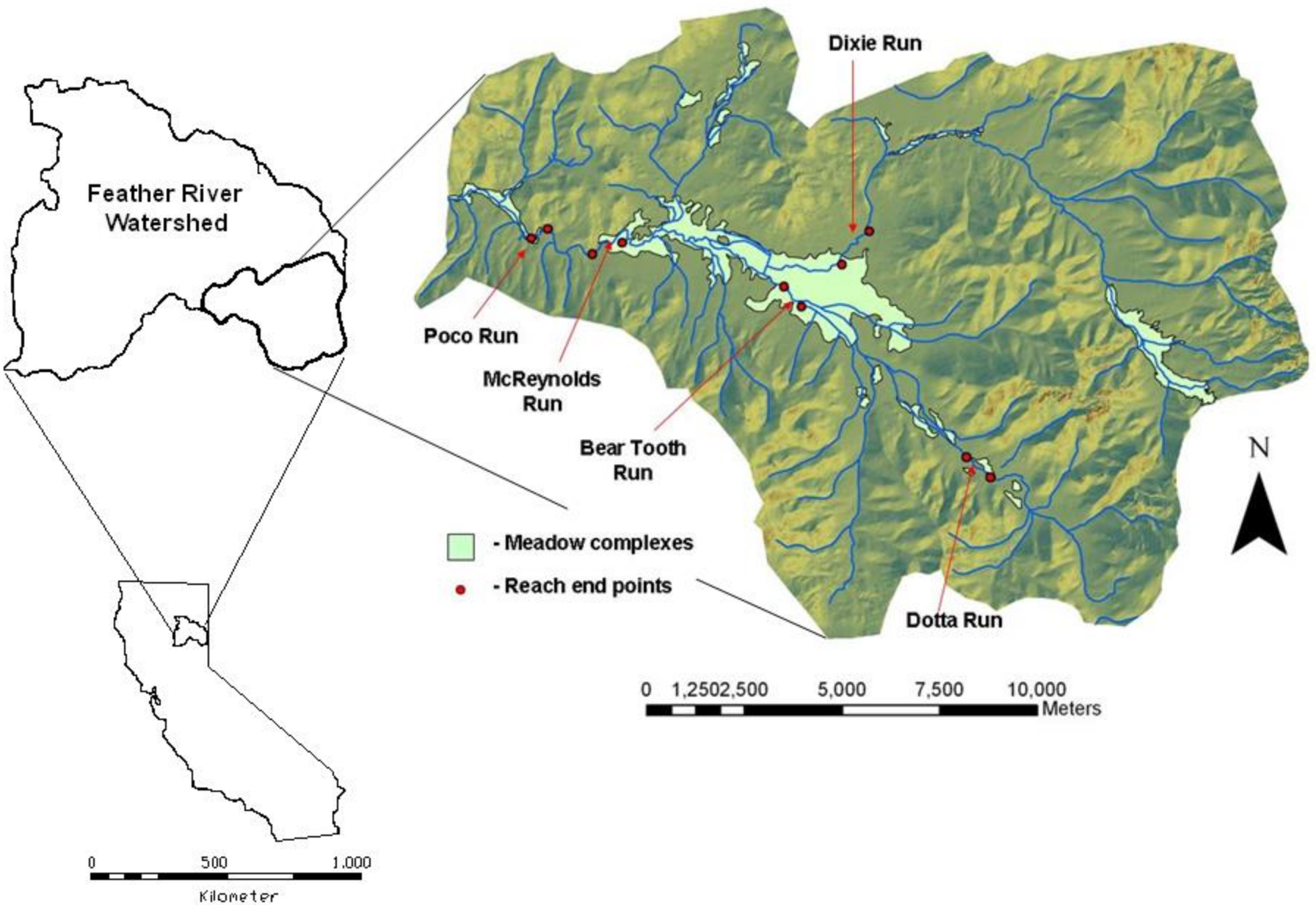
- USFS General Technical Report or Regional Earth Science Monograph
- Extended to Spring 2014

RED CLOVER VALLEY STREAMFLOW MEASUREMENTS

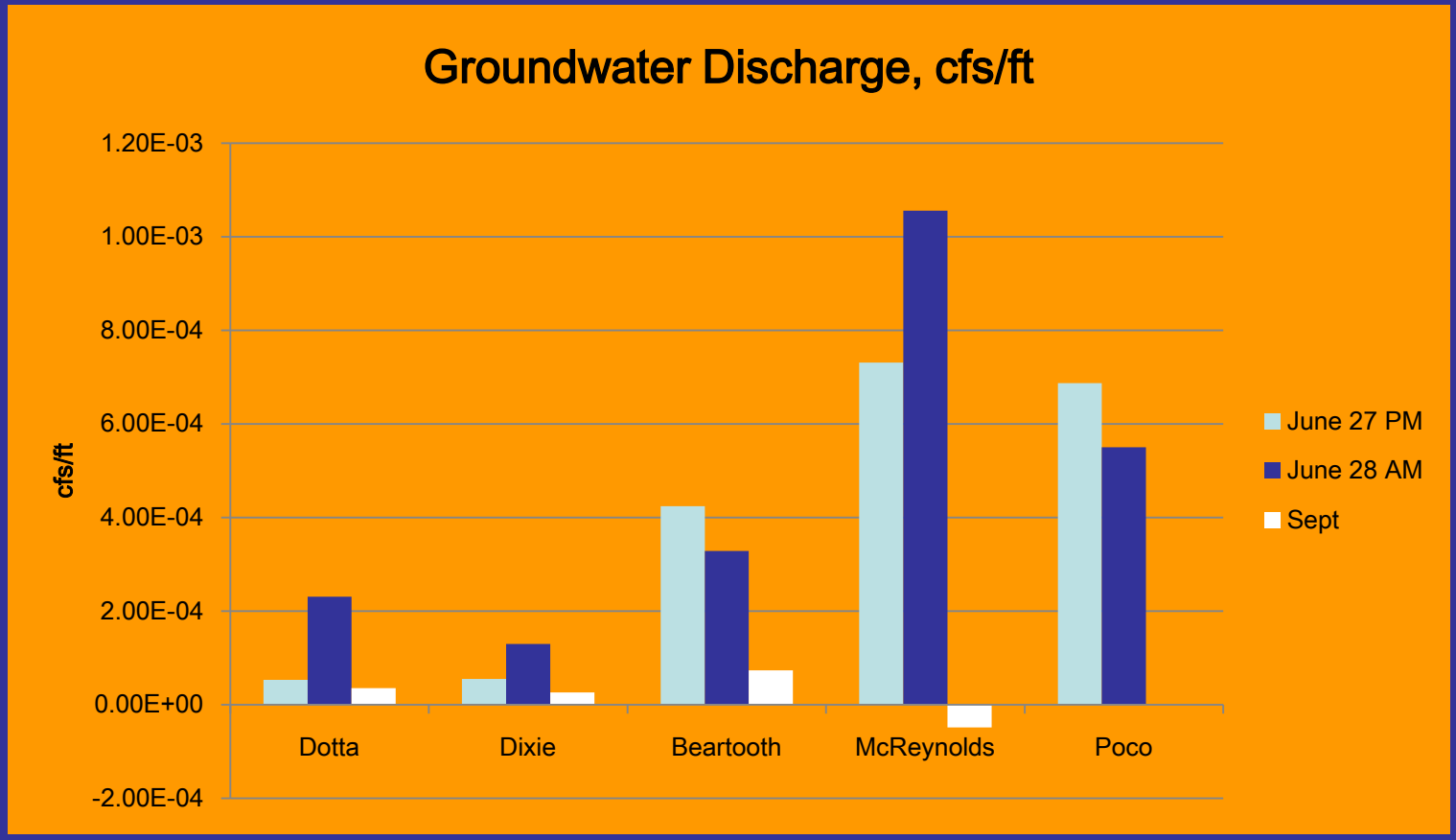
- Streamflow measurements during steady flow conditions
- Restored and unrestored parts of the meadow
- Groundwater levels monitored in shallow wells installed in meadow alluvium near the stream

MEASUREMENT REACHES

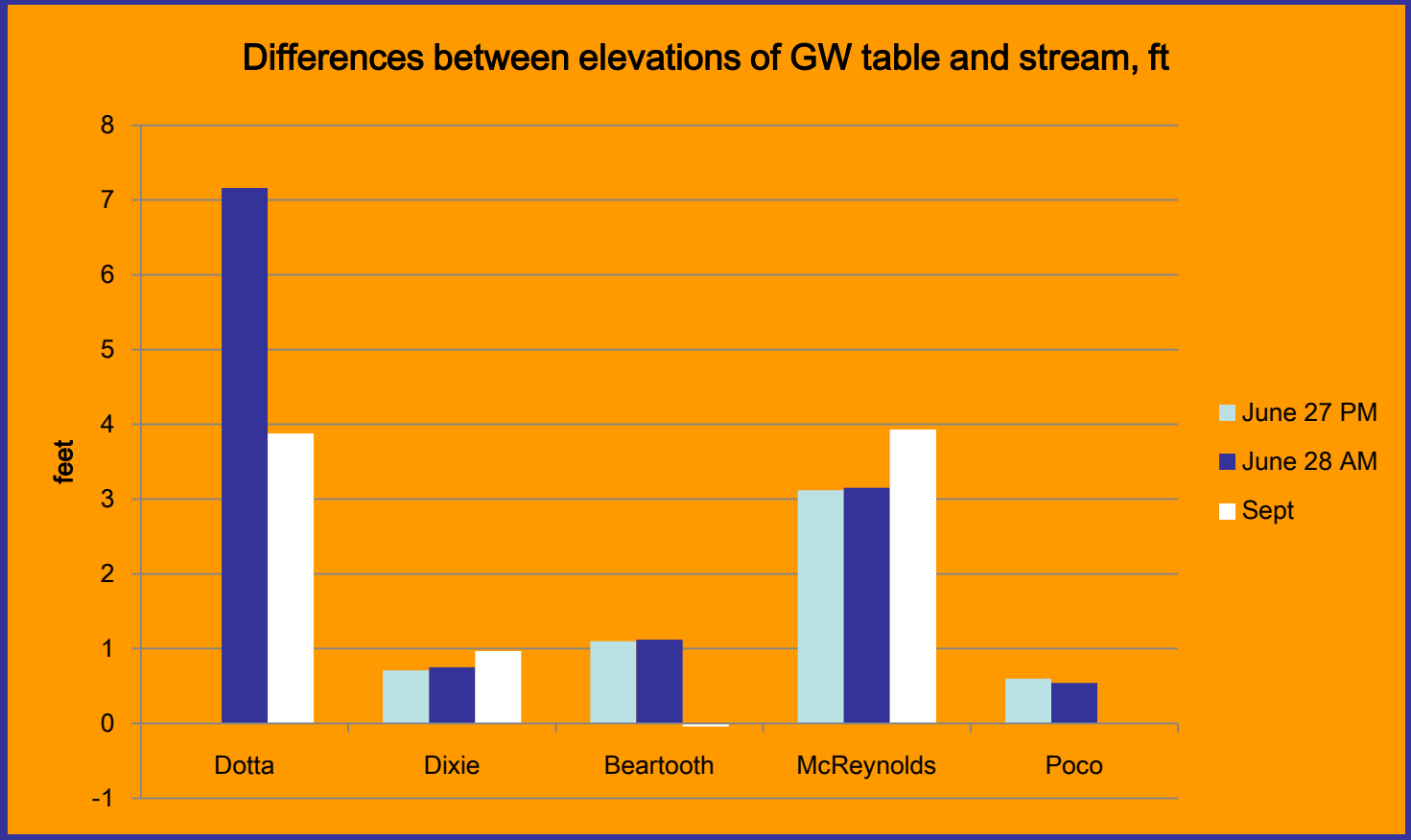
- Unrestored reaches
  - –Dotta
  - –Dixie (main channel and diversion)
  - – Beartooth
- Restored reaches
  - –McReynolds (2006)
  - –Poco (2010)


Feather River
Watershed
Dixie Run
Poco Run
McReynolds
Run
Bear Tooth
Run
Dotta Run
- Meadow complexes
- Reach end points
N
0 1,2502,500 5,000 7,500 10,000
Meters
0 500 1,000
Kilometer

Changes in streamflow within measured reaches per length of stream channel



Differences between groundwater elevations in the meadow and the water surface in the stream



SUMMARY

- Previous studies generally showed greater baseflow volumes or duration after restoration
- Remotely sensed meadow delineation overpredicts areas
- About 190,000 meadow acres on NFS lands
- About half eroded to depths of > 2 ft
- Potential increase of 76,000 ac-ft of storage→ET loss?
- Most ponds in restored meadows recharge groundwater
- Eroded meadows deplete groundwater storage and have lower streamflow early in the summer, higher in later summer
- Long-term effects of restoration still unknown
- Restoration prioritization can consider meadow size, erosion depth to improve flow effects

Contact information for meadow hydrology assessment:

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USGS	Hedeff Essaid
UNR	Sherm Swanson

Thank you