Assessing Impacts of Landuse Changes on Hydrology in the Upper San Pedro Watershed

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Outline

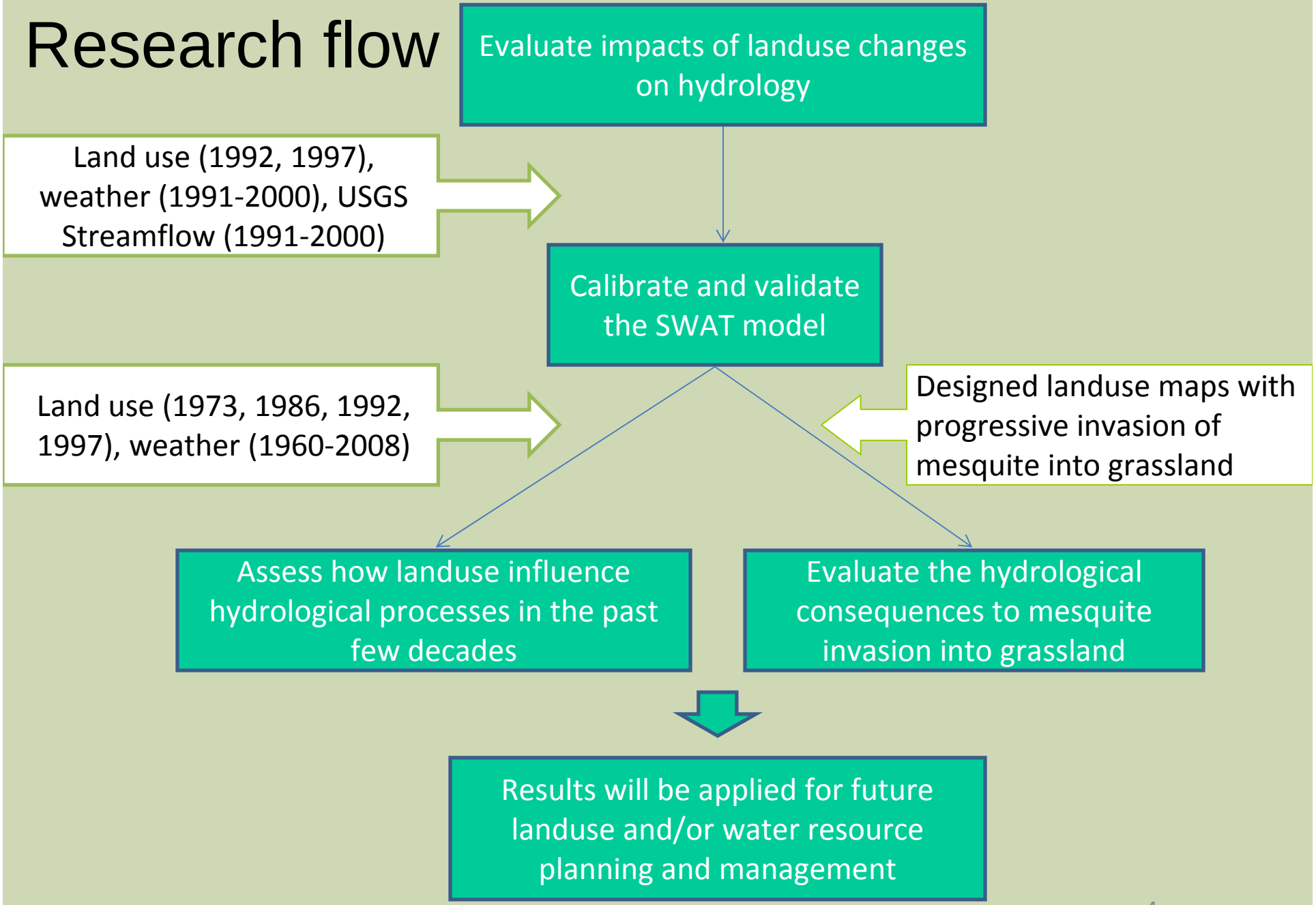
- Introduction
- Study Site
- Research Methods
- Results and Discussion
- Conclusion and Implication

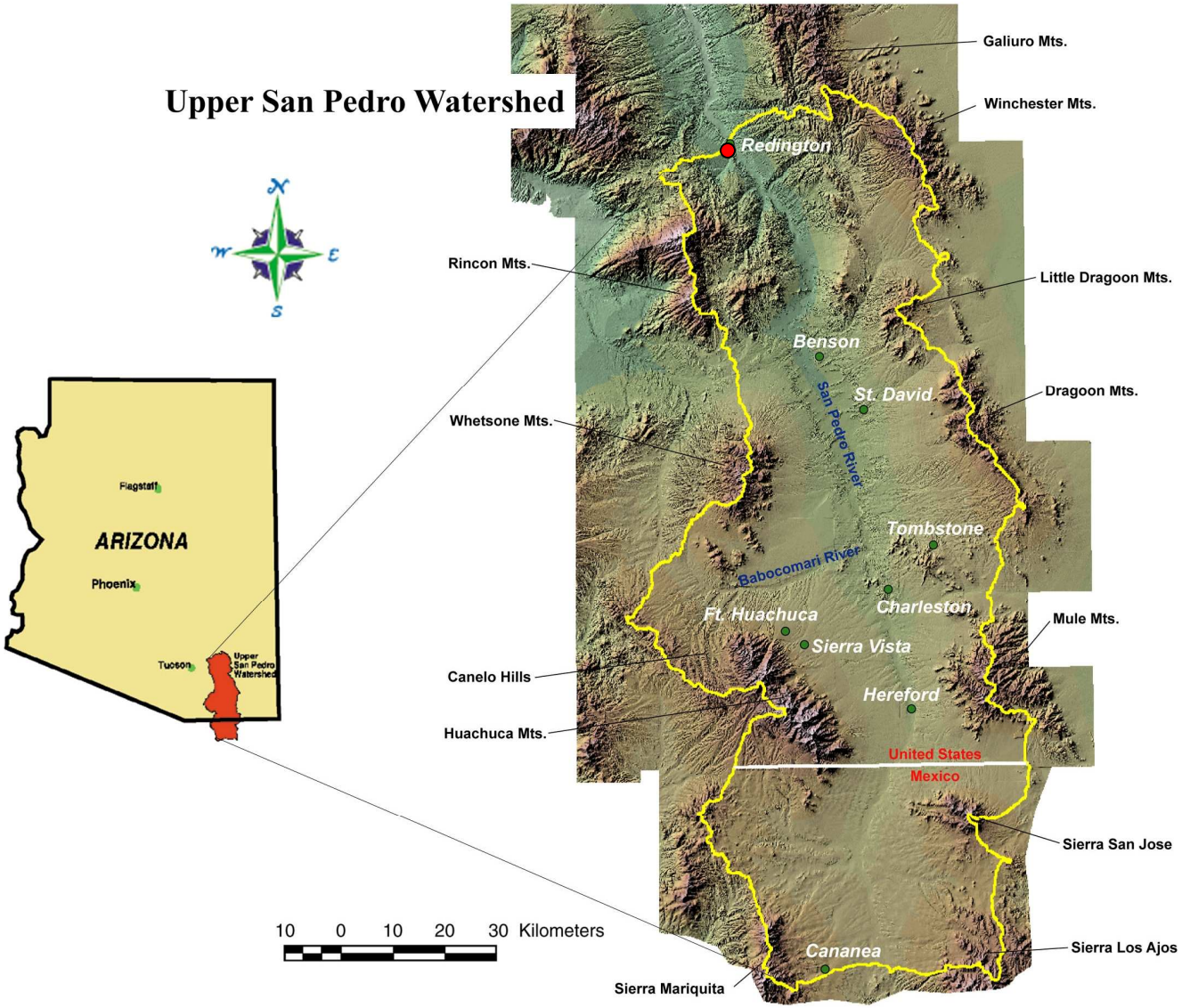
USEPA's Ecosysem Services Research Project

- **Estimating Ecosystem Services (ES).**
- **Understanding potential ES changes due to land-use and climate changes.**
- **Studying potential strategies to minimize degradation of ES.**

Objective of this study:
To assess the impacts of landuse changes
on hydrology over the past few decades.

Research flow





Area

7,600 km²

Elevations

900 - 2900 m

Annual Rainfall

300 - 750 mm

Figure 1. Location of the Upper San Pedro River Basin, from Kepner et al. (2003).

Soil and Water Assessment Tool

The Soil and Water Assessment Tool (SWAT) version 2005 was used to simulate streamflow and sediment in the present study (Neitsch et al., 2005).

The SWAT model is a continuous, long-term, physically based distributed model developed to assess impacts of climate and land management on hydrological processes, sediment loading, and pollution transport in watersheds [Arnold et al., 1998].

The simulated hydrological components include evapotranspiration (ET), surface runoff, percolation, lateral flow, groundwater flow (return flow), transmission losses, and ponds [Arnold et al., 1998].

Upper San Pedro Watershed (SWAT)

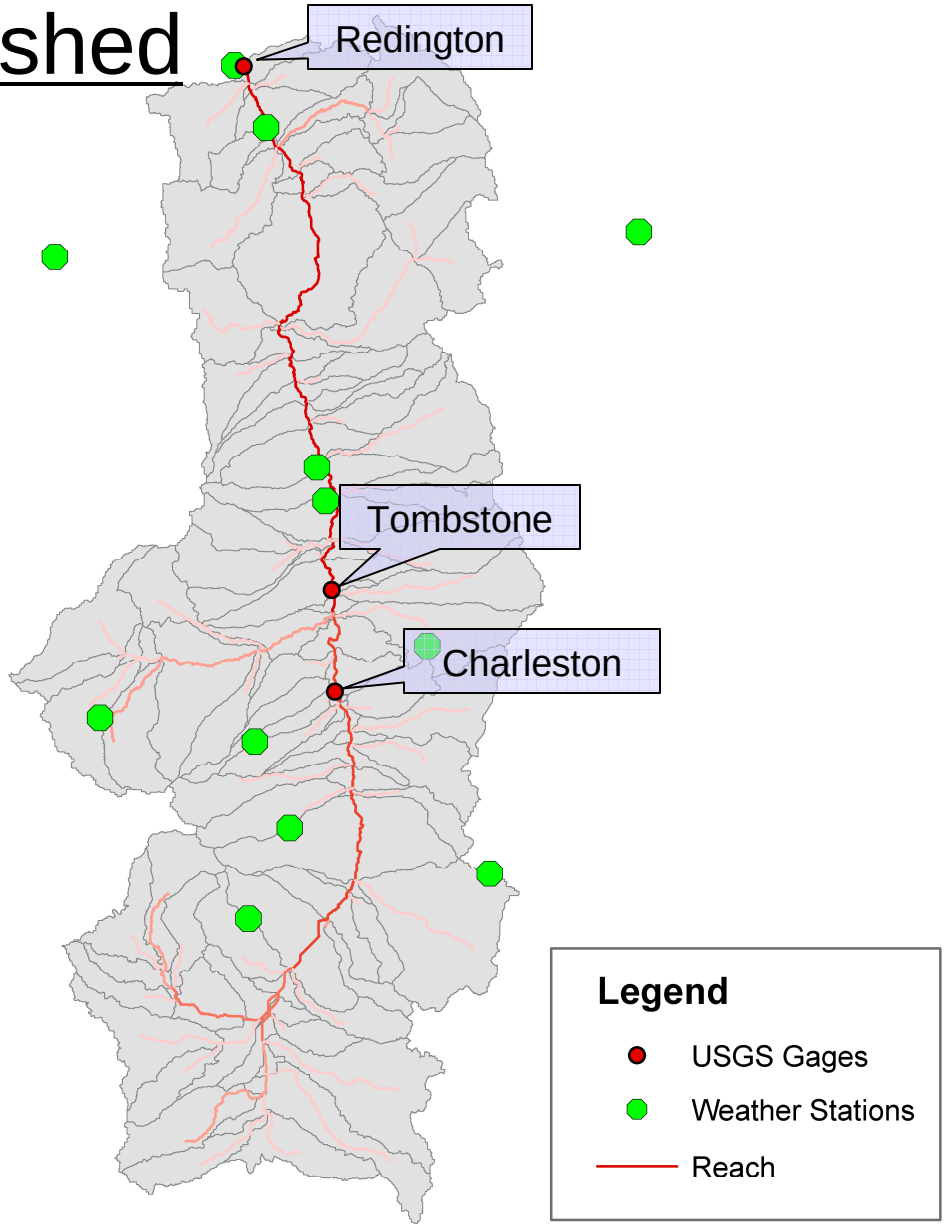
116 subbasins–12 digit HUCs

12 weather stations

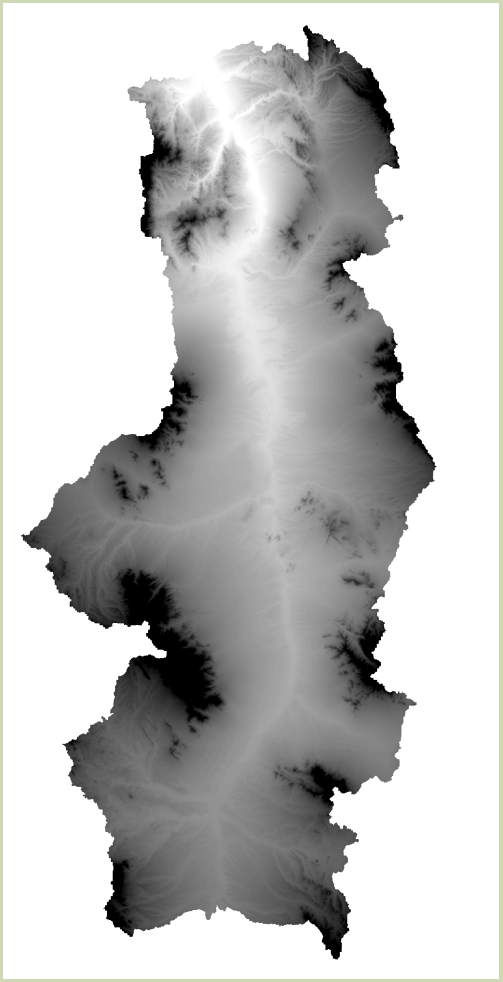
(1960/01 – 2008/04)

USGS gages

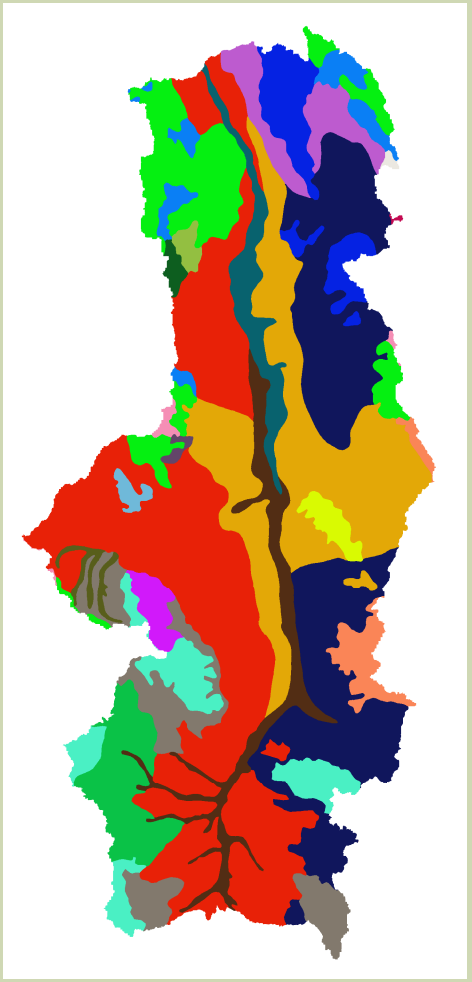
- *Redington (01/91 - 09/95)*
- *Tombstone (10/96 – 12/00)*
- *Charleston (01/91 – 12/00)*



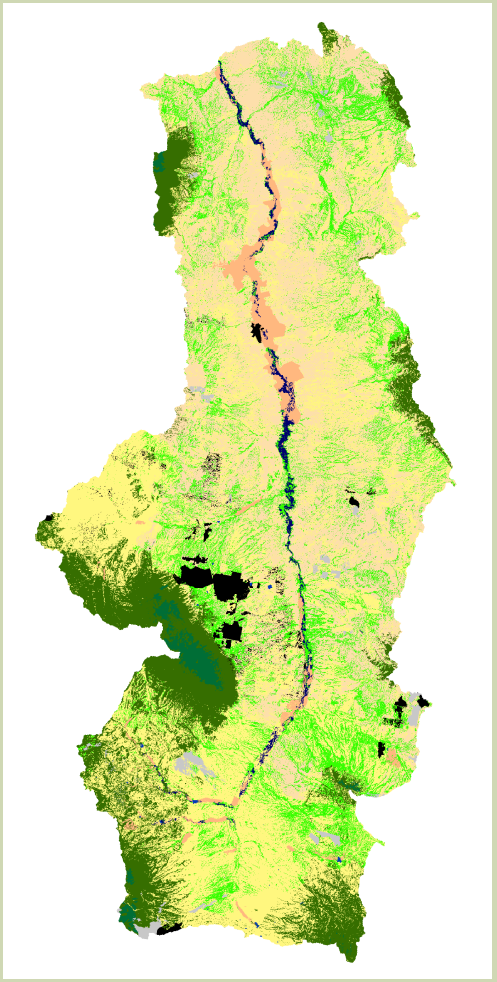
Model Inputs



DEM



Soil (STATSGO)



LULC (NALC)

Calibration/Validation Results

Table 1. Criteria for examing the accuracy of calibration and validation.

Index	Calibration (1991-1995)		Validation (1996-2001)	
	Redington	Charleston	Tombstone	Charleston
NS Coefficient	0.63	0.58	0.81	0.70
R^2	0.66	0.82	0.90	0.93
PBIAS	-5.10	9.56	10.70	7.94

Calibration/Validation Results

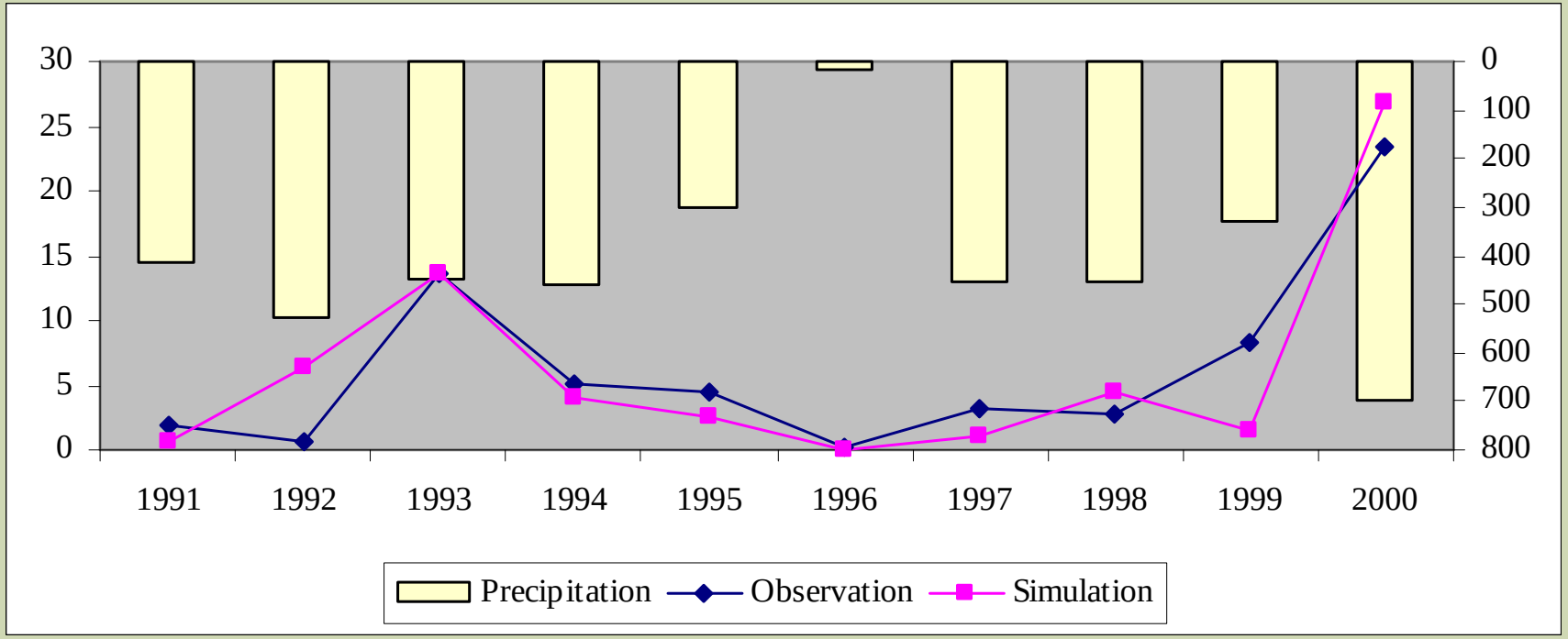


Figure 2. Annual precipitation, simulated and observed annual streamflow at the USGS Redington (1991-1995) and Tombstone (1996-2000) gage.

Calibration/Validation Results

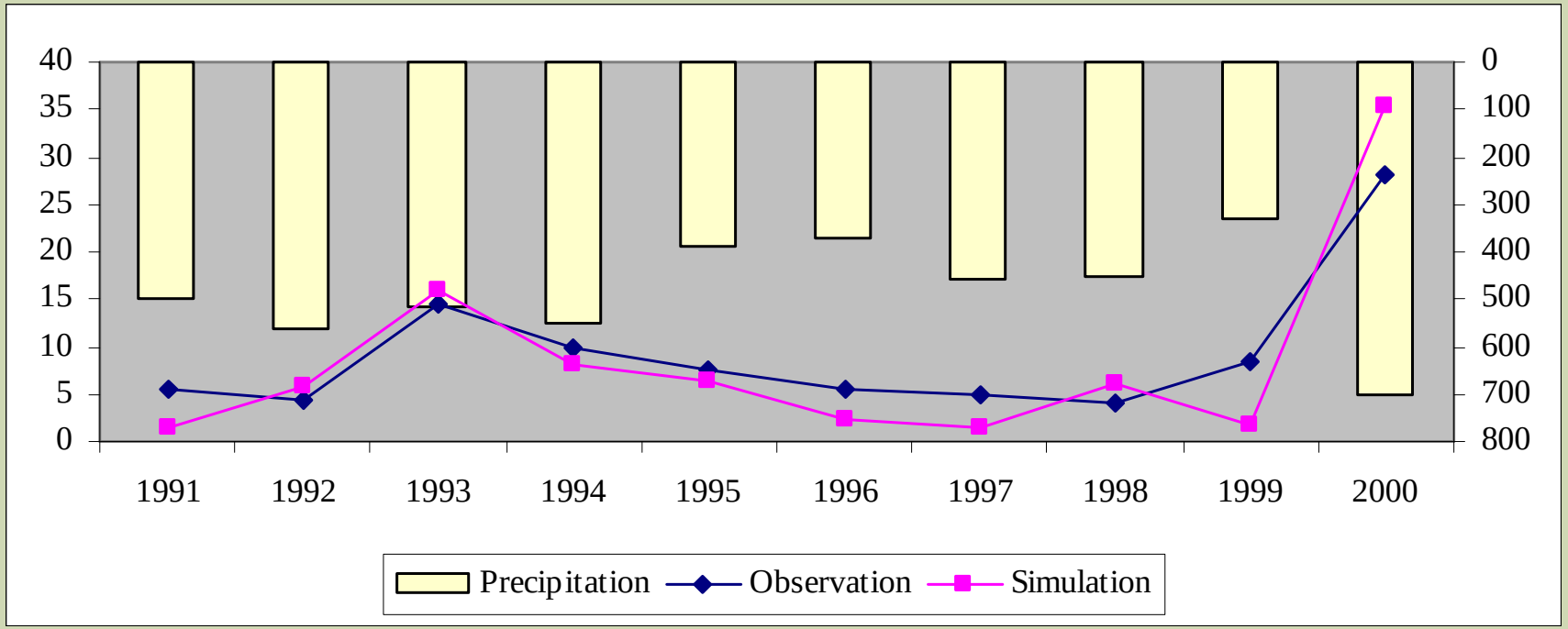


Figure 3. Annual precipitation, simulated and observed annual streamflow at the USGS Charleston gage (1991-2000).

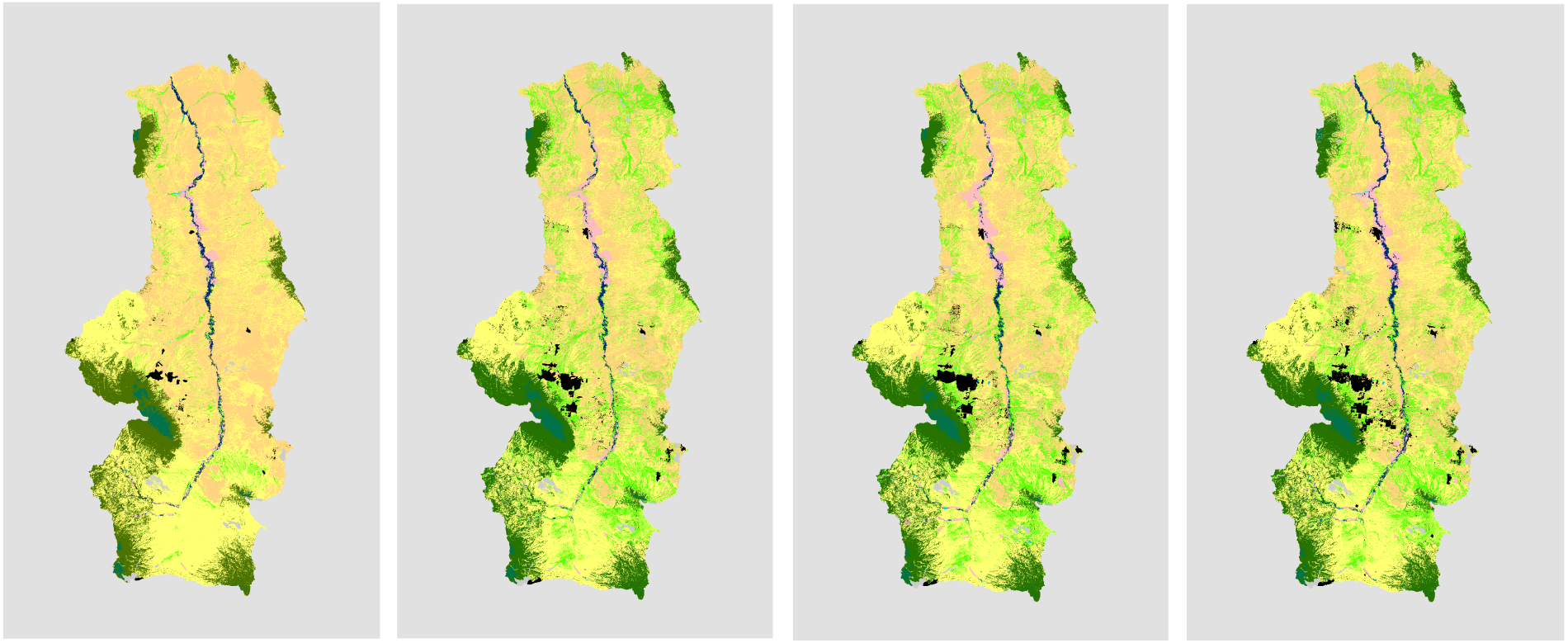


Figure 4. Four land cover in the upper San Pedro Watershed, modified from Kepner et al. (2002)

Hydrological Components

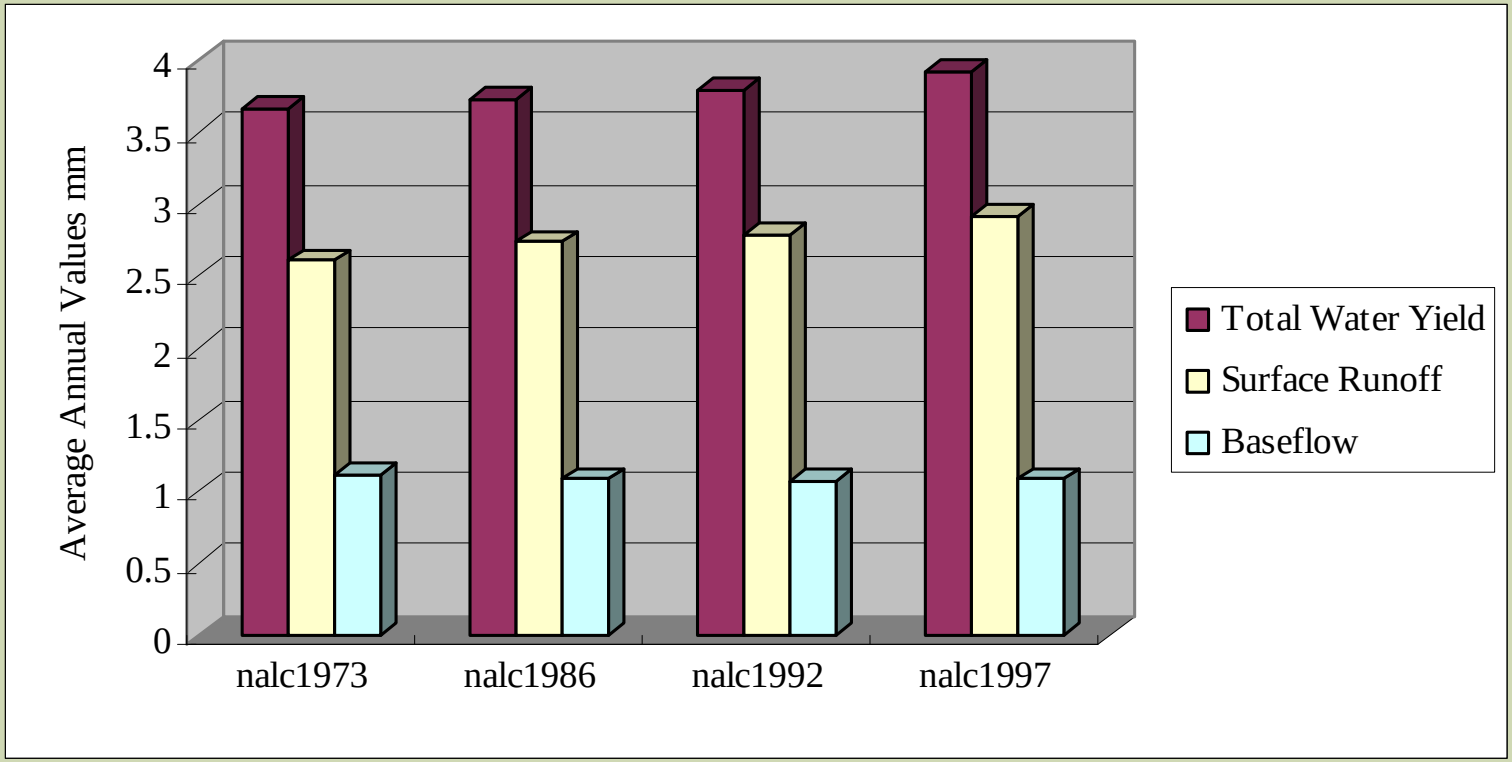


Figure 5. Average annual values of total flow (water yield), surface runoff, and baseflow for four past landuse scenarios in the upper San Pedro Watershed.

Land Cover Change

Table 2. Land cover extent as total hectares and percent relative land cover change for the upper San Pedro Watershed in the period from 1973 to 1997.

Landuse	Area (Hectare)				Percent			
	1973	1986	1992	1997	86-73	92-86	97-92	97-73
Mesquite	20789	106090	105394	103679	410.31	-0.66	-1.63	***398.71***
Grassland	304109	259129	255939	258662	-14.79	-1.23	1.06	-14.94
Desertscrub	293959	242079	238428	235062	-17.65	-1.51	-1.41	-20.04
Agriculture	8709	13603	18162	14500	56.20	33.51	-20.16	66.49
Urban	3269	10097	12278	16573	208.86	21.60	34.98	***406.96***

Modified from Kepner et al. (2002)

Land Cover Extent Change

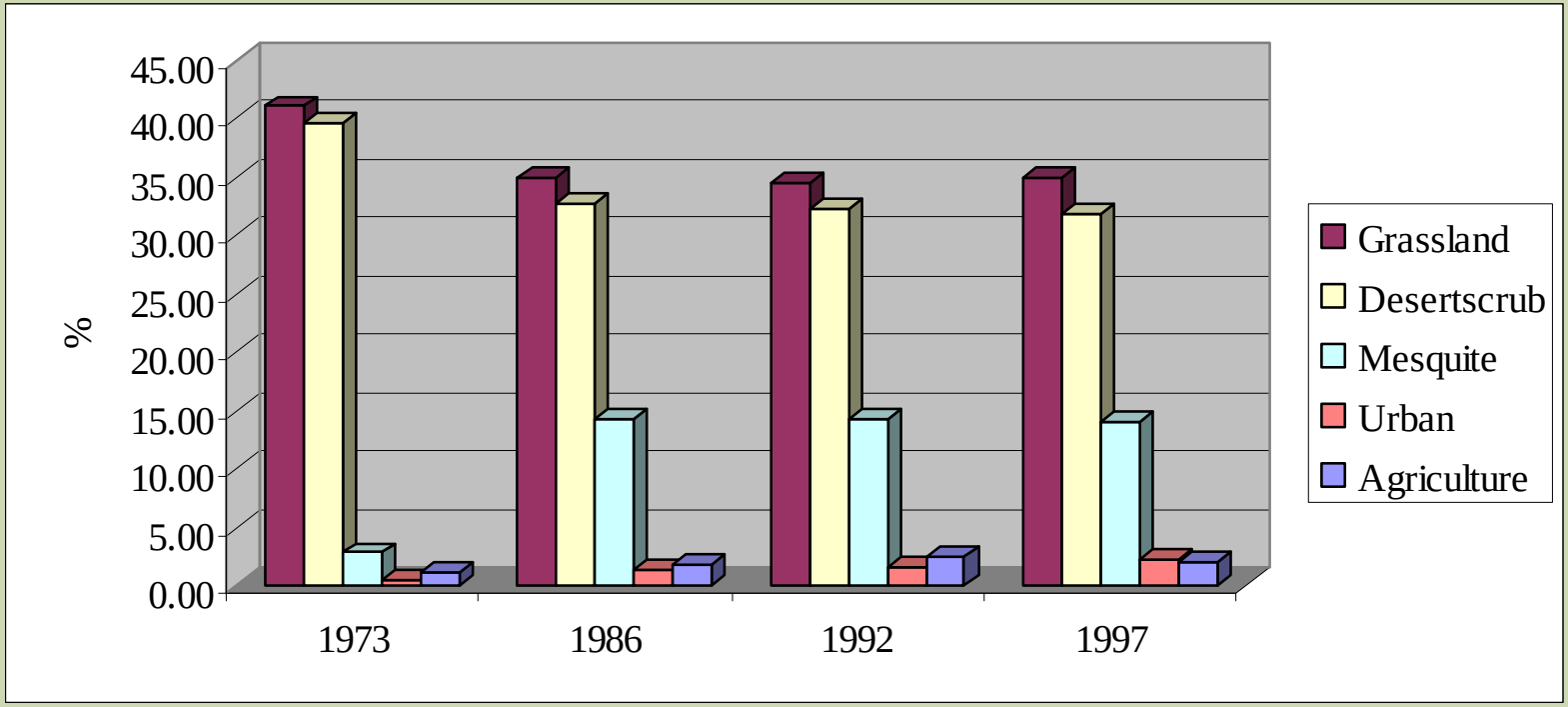


Figure 6. Changes in proportional extent for five land cover classes in the upper San Pedro Watershed (1973-1997). (Modified from Kepner et al., 2002)

Urbanization and Runoff

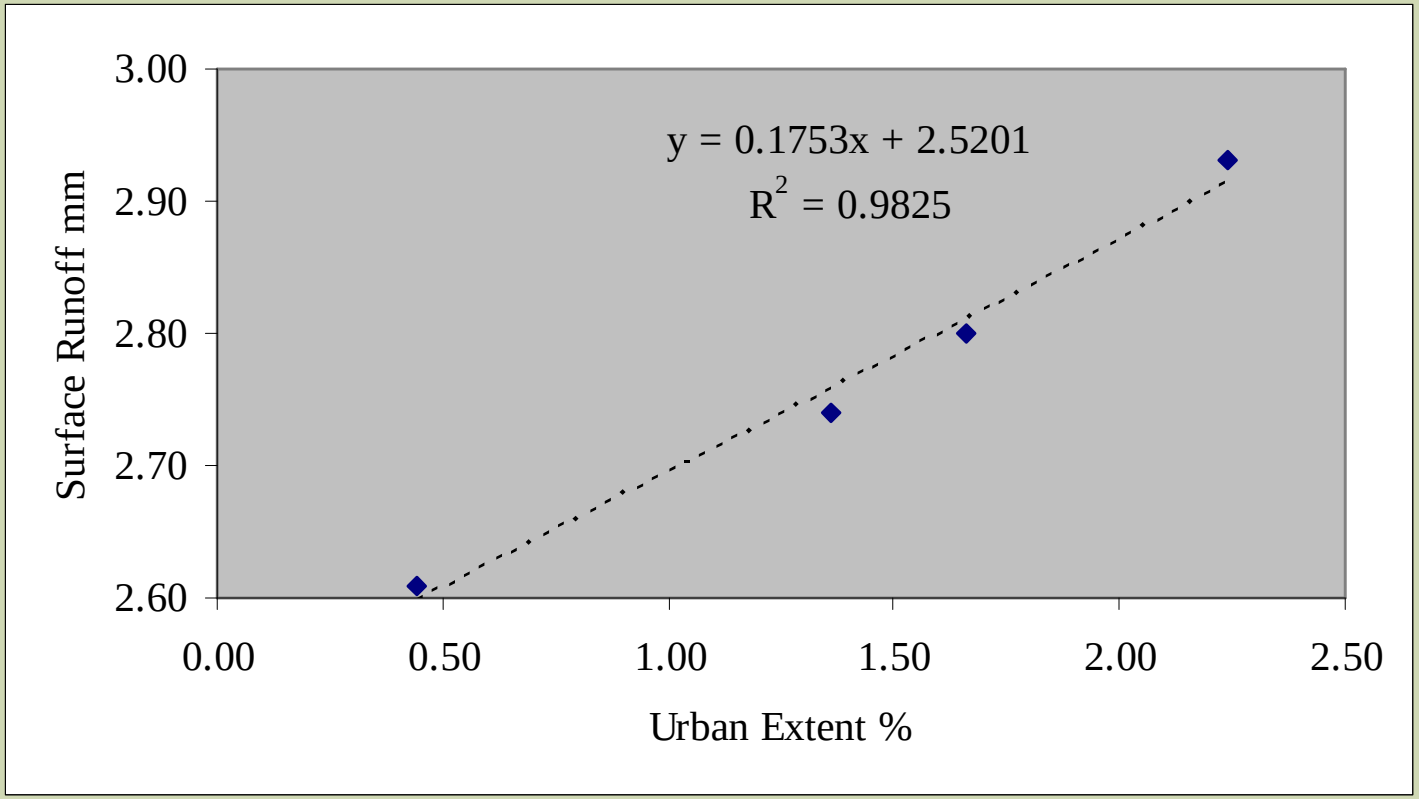
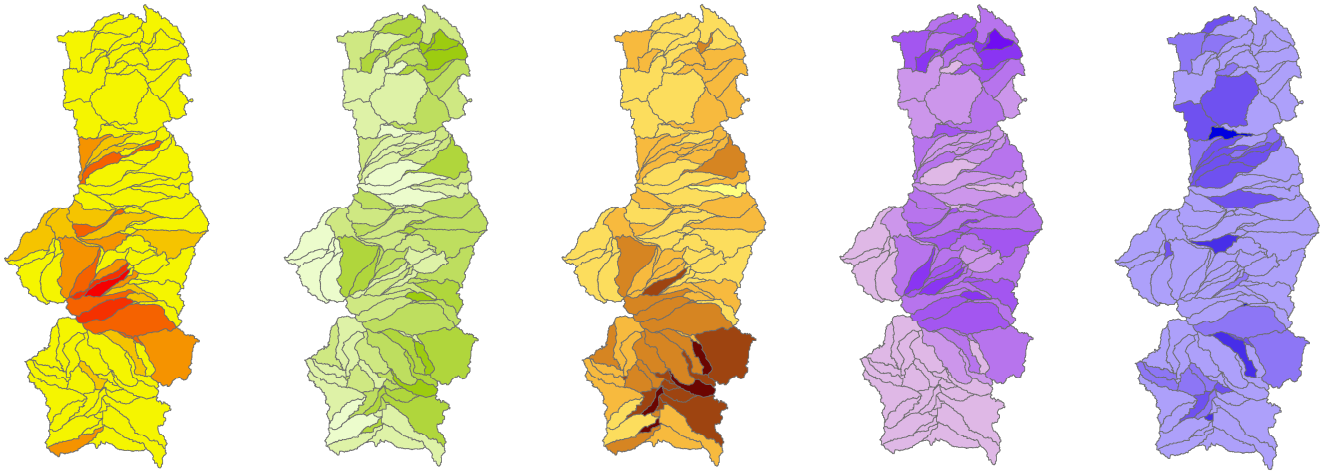


Figure 7. Relationship between proportional urban extent and average annual surface runoff (1960-2008) for four landuse scenarios in the upper San Pedro Watershed.



URLD %Sub.Area

-0.04 - 0.92
0.93 - 3.23
3.24 - 5.85
5.86 - 11.16
11.17 - 17.28
17.29 - 34.06

MESQ %Sub.Area

-2.69 - 2.69
2.70 - 7.12
7.13 - 11.89
11.90 - 17.12
17.13 - 26.20
26.21 - 45.21

RNGE %Sub.Area

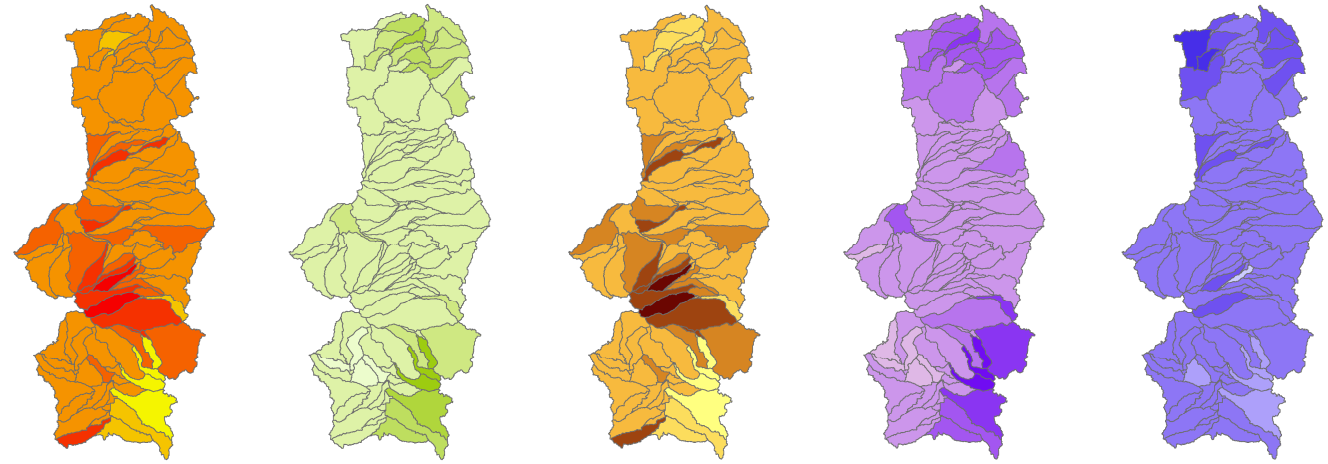
1.41 - 42.35
-3.20 - 1.40
-8.29 - -3.21
-14.23 - -8.30
-25.87 - -14.24
-44.46 - -25.88

RNGB %Sub.Area

-2.89 - 3.58
-8.11 - -2.90
-12.92 - -8.12
-20.46 - -12.93
-47.16 - -20.47
-47.17

AGRR %Sub.Area

-43.33
-43.32 - 0.50
0.51 - 1.95
1.96 - 4.51
4.52 - 7.62
7.63 - 14.60



Surface Runoff mm

-1.53 - 0.29
0.30 - 0.40
0.41 - 0.60
0.61 - 0.99
1.00 - 2.13
2.14 - 5.73

Baseflow mm

0.03 - 0.07
-0.02 - 0.02
-0.09 - -0.03
-0.24 - -0.10
-0.66 - -0.25
-0.81 - -0.67

Water Yield mm

-2.35 - -1.19
-1.18 - -0.09
-0.08 - 0.29
0.30 - 0.99
1.00 - 2.13
2.14 - 5.73

Percolation mm

0.10 - 0.33
-0.12 - 0.09
-0.46 - -0.13
-1.36 - -0.47
-4.16 - -1.37
-4.82 - -4.17

Evapotranspiration mm

8.59 - 33.08
3.61 - 8.58
-1.67 - 3.60
-19.72 - -1.68
-83.44 - -19.73
-83.45

Conclusion and Implication

Although mesquite invasion (2.81–14.33% from 1973-1986) was the most significant landuse changes in the Upper San Pedro watershed in the period from 1973 to 1997, increased surface runoff and total water yield were mainly attributed to urbanization (0.44 – 2.24% from 1973-1997).

The increased runoff is considered as a good thing because as population increases, more water is needed to sustain human beings. However, the increased runoff may cause higher erosion and sediment which degrades surface water quality.

Acknowledgement

- We are grateful for the guidance and leadership of Nita Tallent-Halsell, SwESP Lead on issues related to southwestern ecology.

- We appreciate the help from many other people, including Maliha Nash, Paula Allen, and Li-Chi Chiang from LEB, EPA.

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Thank You for Your Attention!

Any Questions?