

Effects of flow regulation on a Sonoran riparian ecosystem, Verde River, Arizona.



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Riparian Areas

- Riparian zones are the interfaces between terrestrial and aquatic ecosystems
- Important for ecosystem services and wildlife habitat
- Dominated by cottonwood (*Populus fremontii*) and willow (*Salix gooddingii*)
- Disturbance adapted
 - Regeneration tied to floods



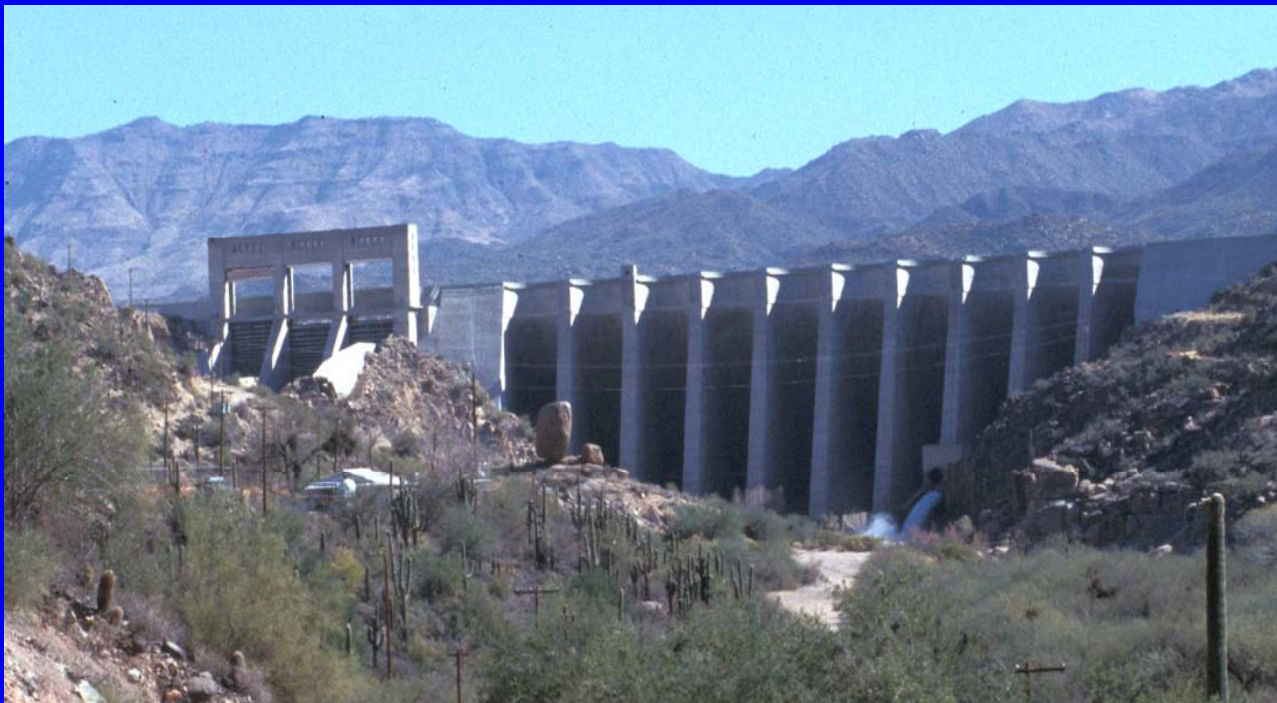
Riparian Areas

- Floods create bare moist germination beds necessary for pioneer species recruitment
- New cohorts of cottonwoods and willows come up with each appropriate flood event (magnitude and timing are important)
- River migration and aggradation creates lateral age zonation of stands across the floodplain



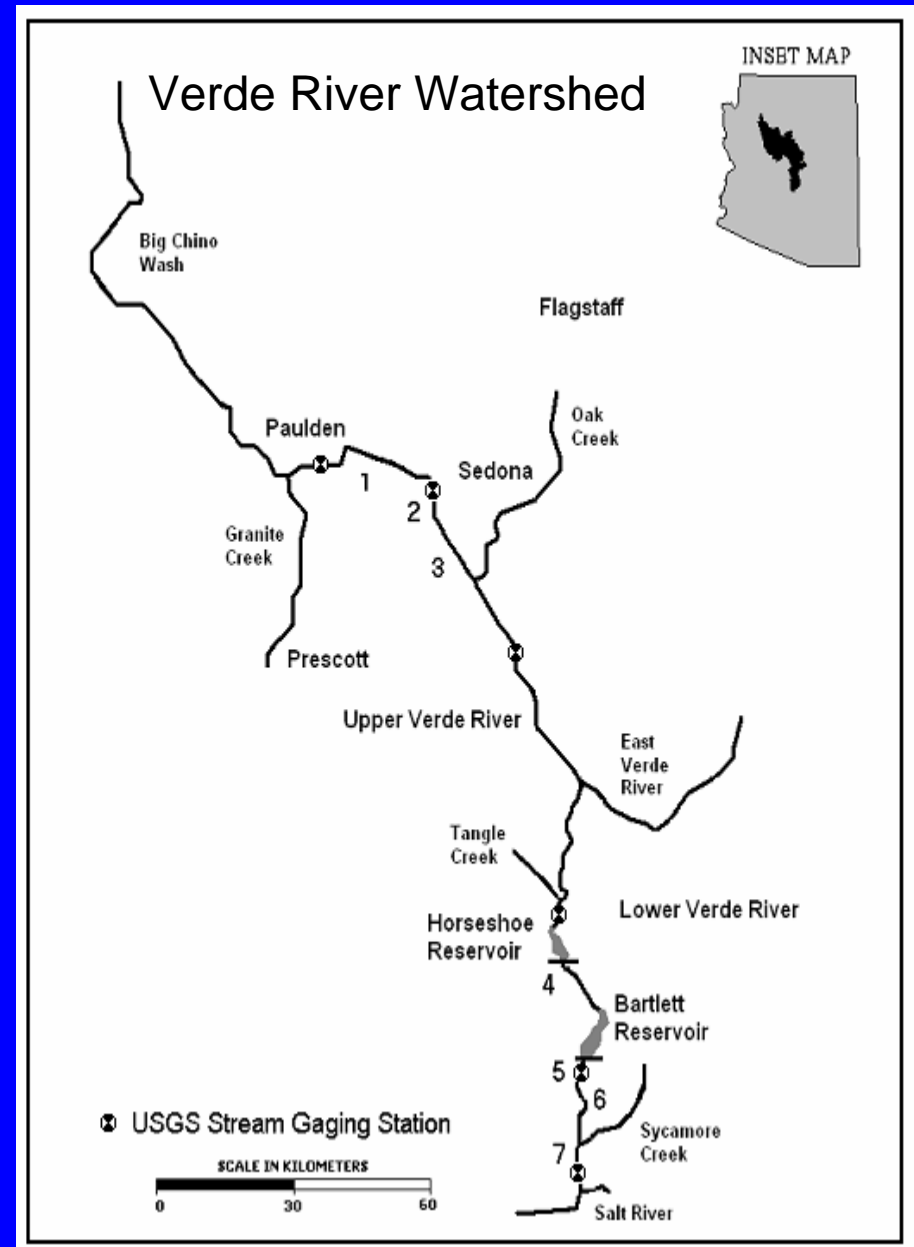
Effects of Dams

- Alter flow regime
 - magnitude, frequency, duration, and timing of floods
- Native vegetation not adapted to the new flow regime
- Decreased germination and survival of *Populus* and *Salix*
- *Tamarix* spreads into below dam areas



Study Sites and Methods

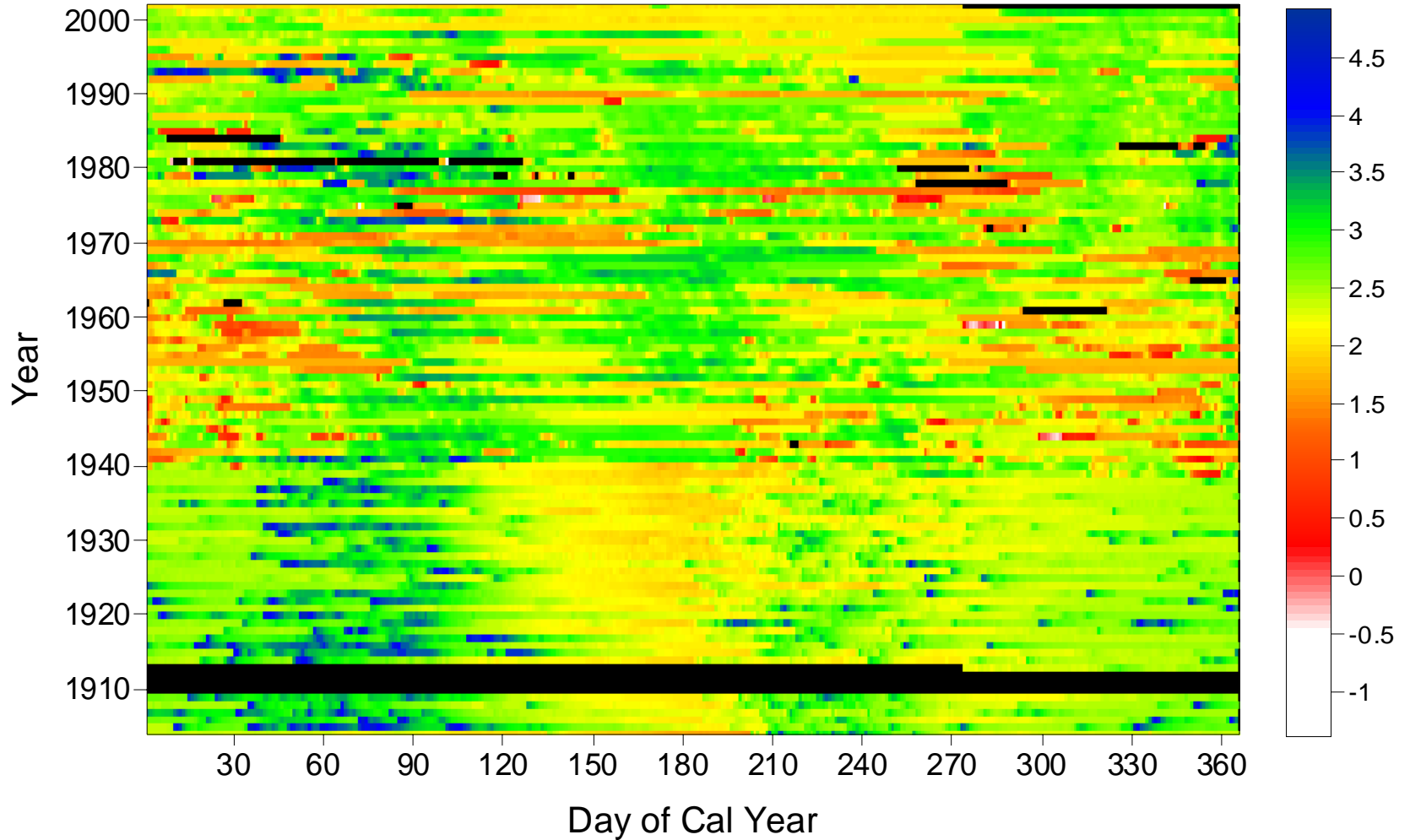
- Hydrology
 - USGS Gauges at Tangle and Bartlett (1945 to 2002)
- Vegetation
 - Upper Basin: Unregulated
 - Three sites (1,170 to 1,100 m)
 - Lower Basin: Regulated
 - Four sites (580 to 440 m)
 - 9 *Populus-Salix* plots per site
 - Sapling (1 to 10 year)
 - Mature (11 to 55 year)
 - Old-growth (55+ year)



Raster streamflow hydrograph

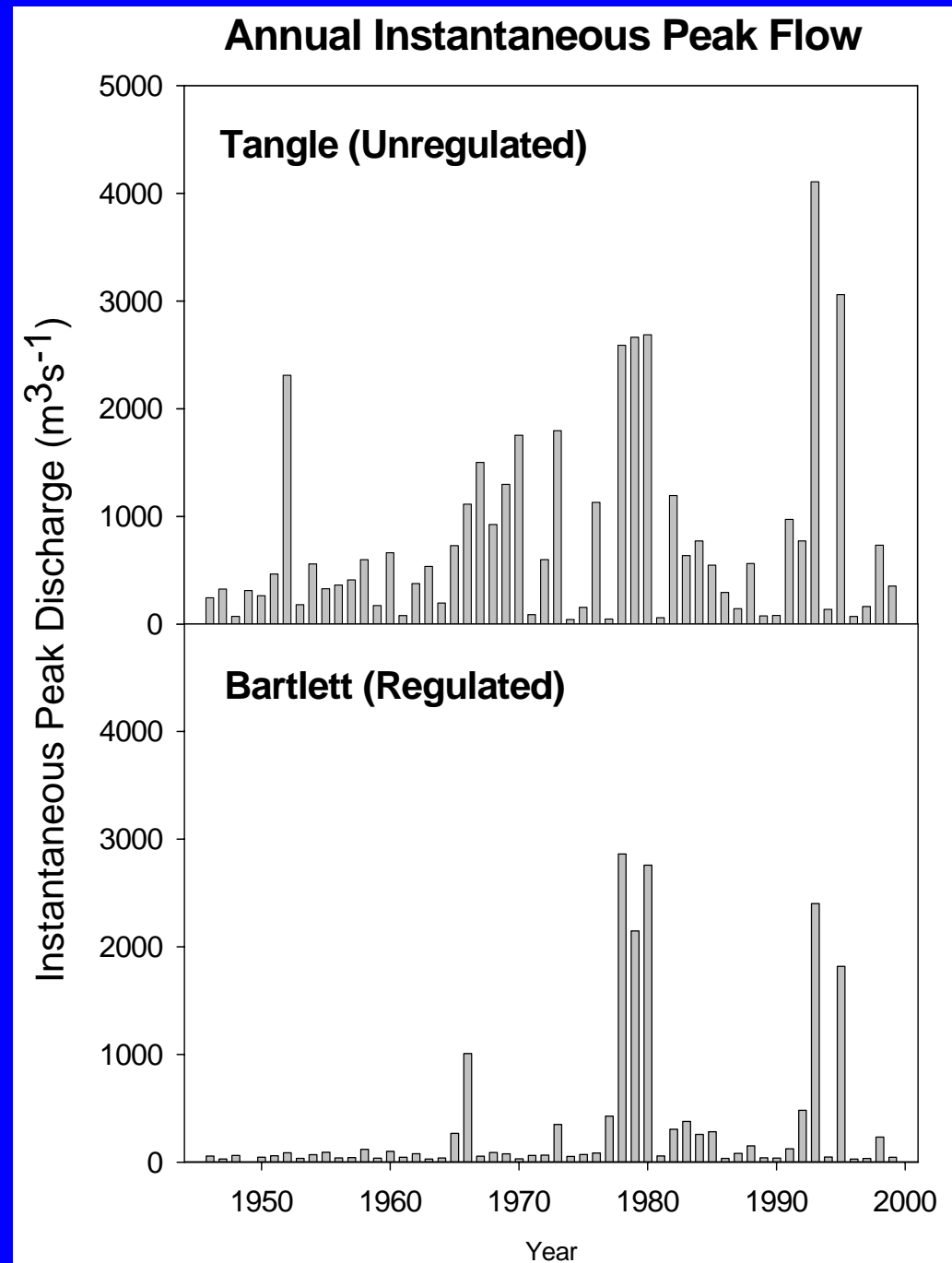
Verde River Below Bartlett Dam, AZ

Log flow
(flow in cfs)



Flow Regime

- Spring peak flows decreased, summer base flows increased
- Spring (Dec-April) peak flows shifted 1 month from early February to early March
- Average annual instantaneous peak flow decreased by 56%
 - moderate-sized floods captured by dam
- Large floods
 - 20% decrease in magnitude
 - No timing shift



Results – Woody Vegetation

How does woody vegetation structure within *Populus-Salix* stands differ between reach types?

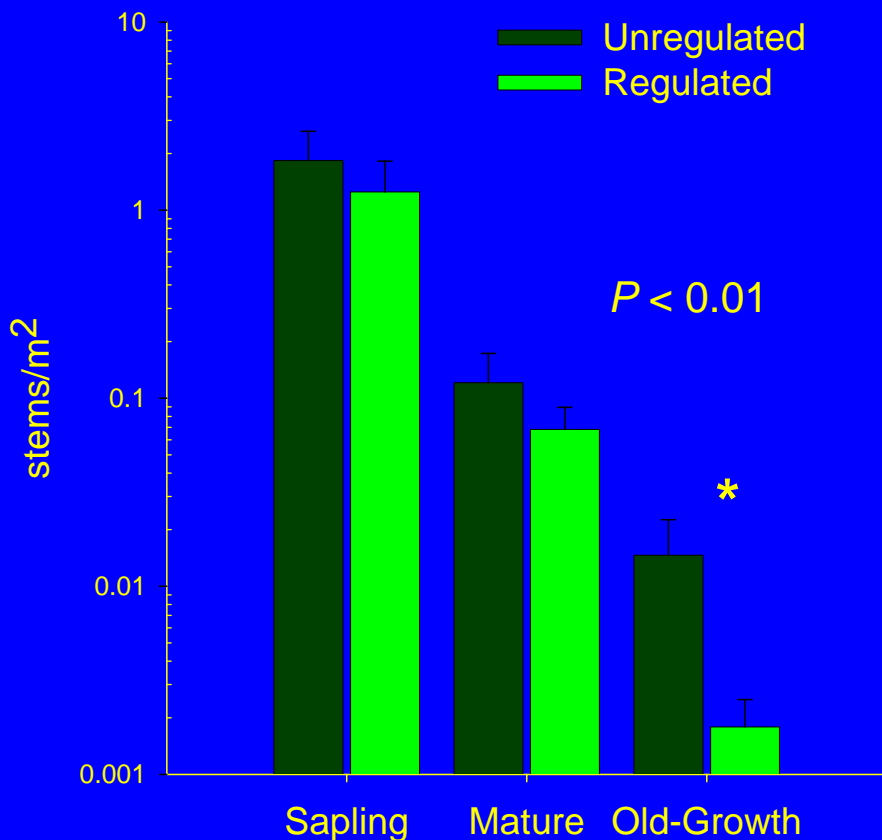


Hypotheses – Woody Vegetation

- As in other riparian ecosystems, flow regulation will lead to a decrease in native pioneer tree recruitment
 - *Populus* and *Salix* density will be lower in the regulated reach
- Alterations to the flow regime will favor invasive species
 - *Tamarix* density will be higher on the regulated reach

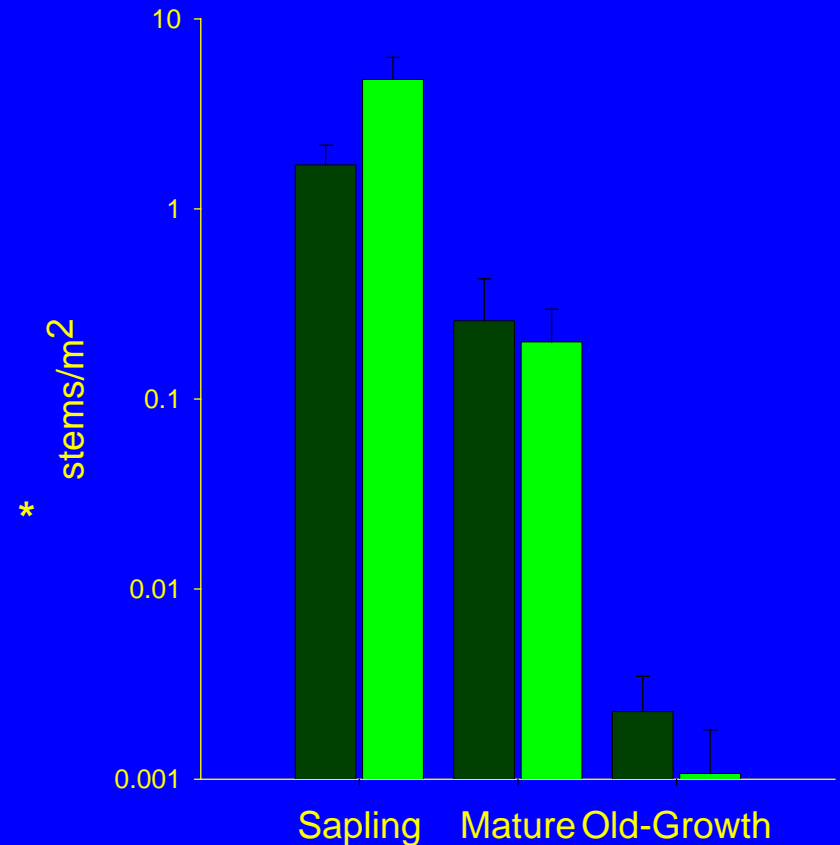
Populus Stem Density (*P. fremontii*)

- No difference in stem density between reaches in sapling and mature stands

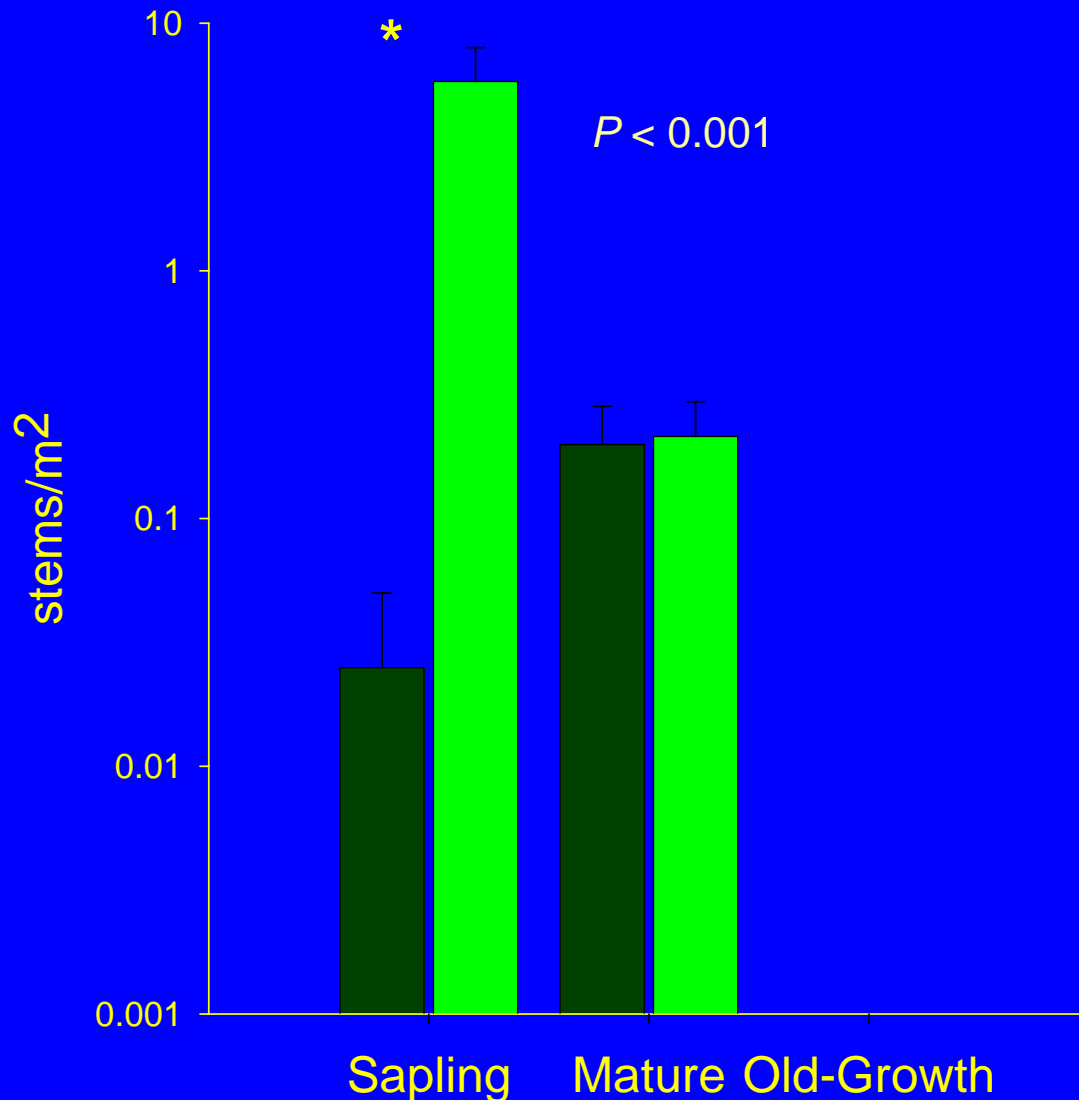


Salix Stem Density (*S. gooddingii* and *S. exigua*)

- Sapling stands show a trend toward higher *Salix* density in regulated reaches

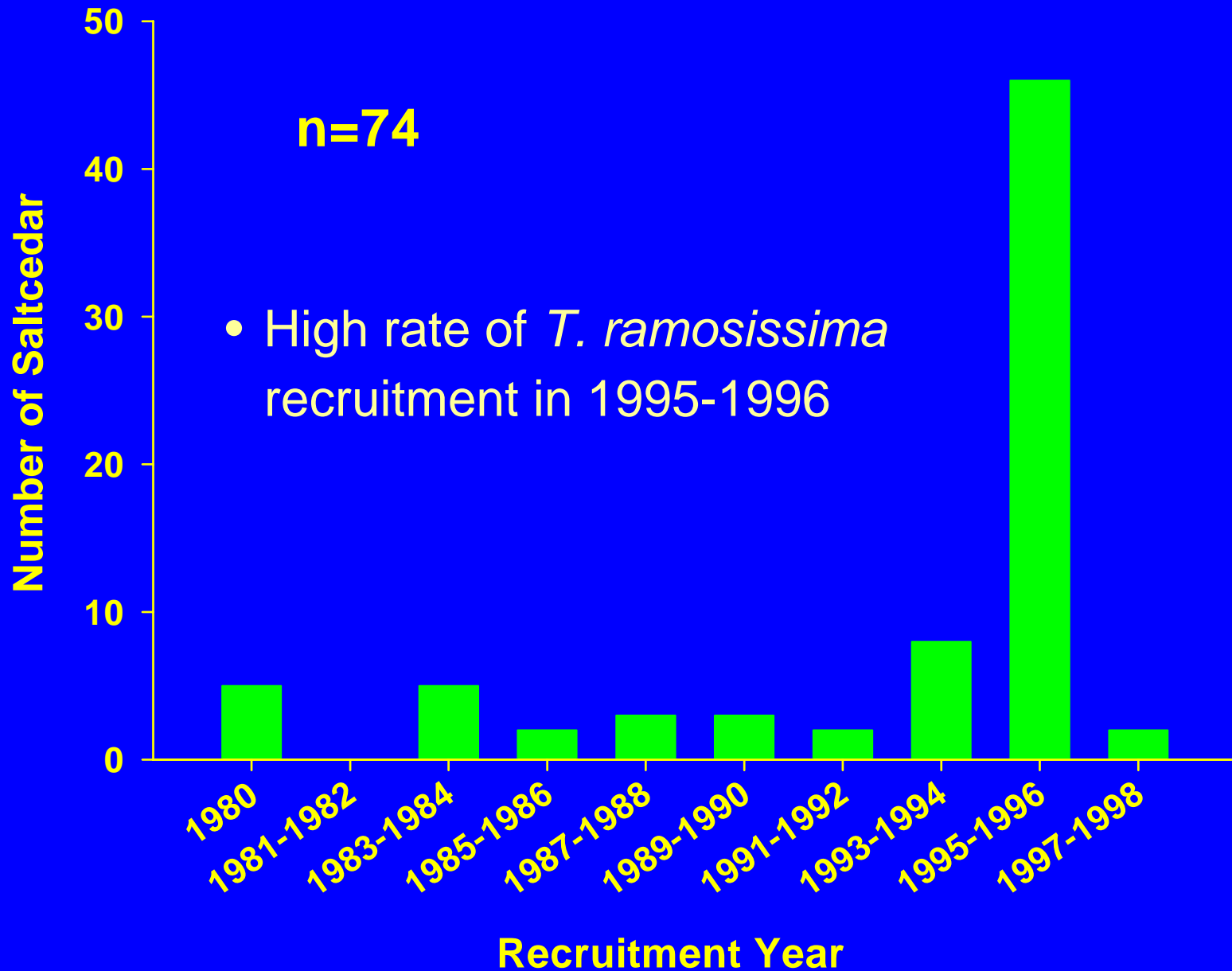


Tamarix ramosissima (Saltcedar) Stem Density within *Populus-Salix* Stands



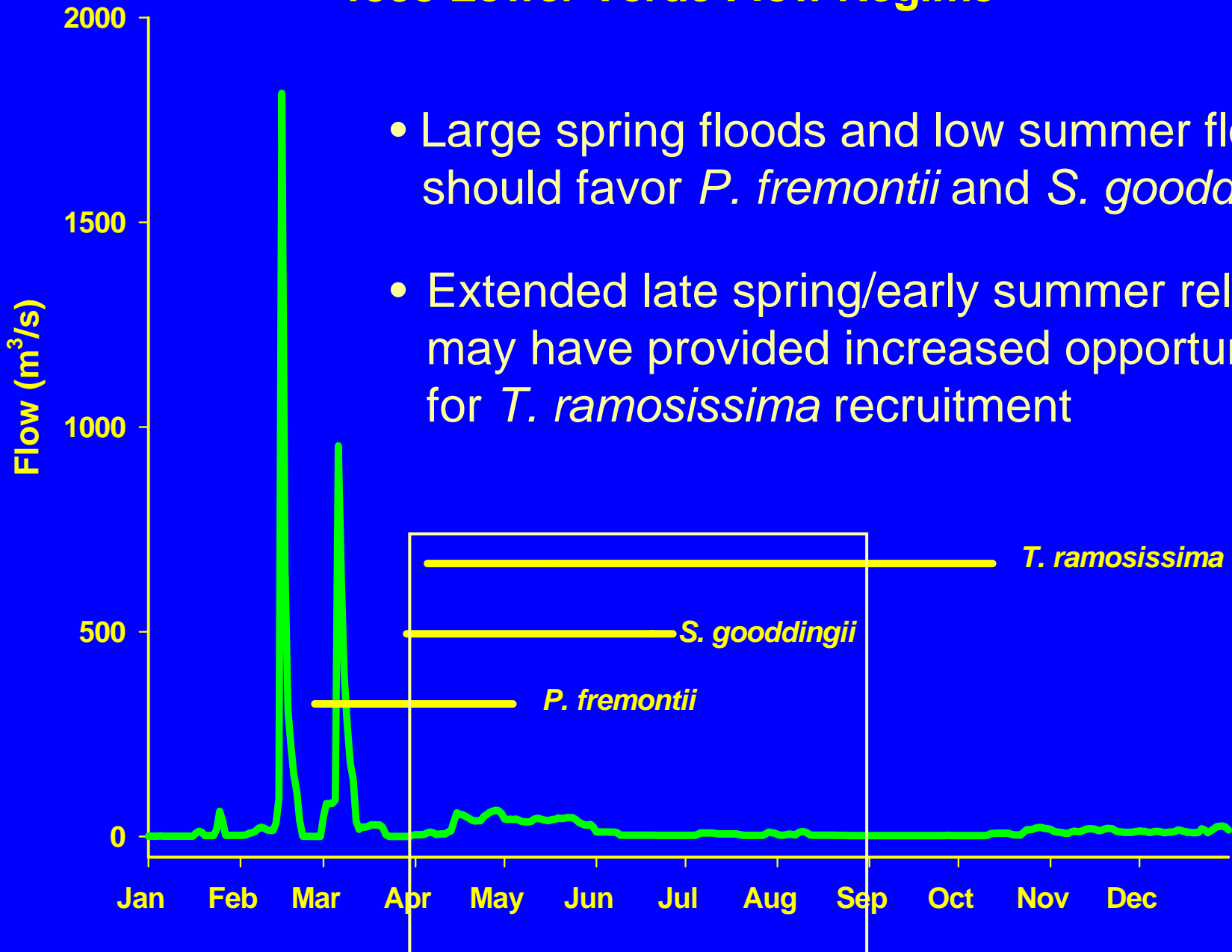
- Within sapling *P-S* stands, *Tamarix* density is 200 fold greater in regulated reaches
- Change in conditions within the last 10 years
 - Favors *T. ramosissima*
 - Not detrimental to *P. fremontii* or *Salix* sp.
 - Only occurred below dam

Lower Verde *Tamarix* Recruitment

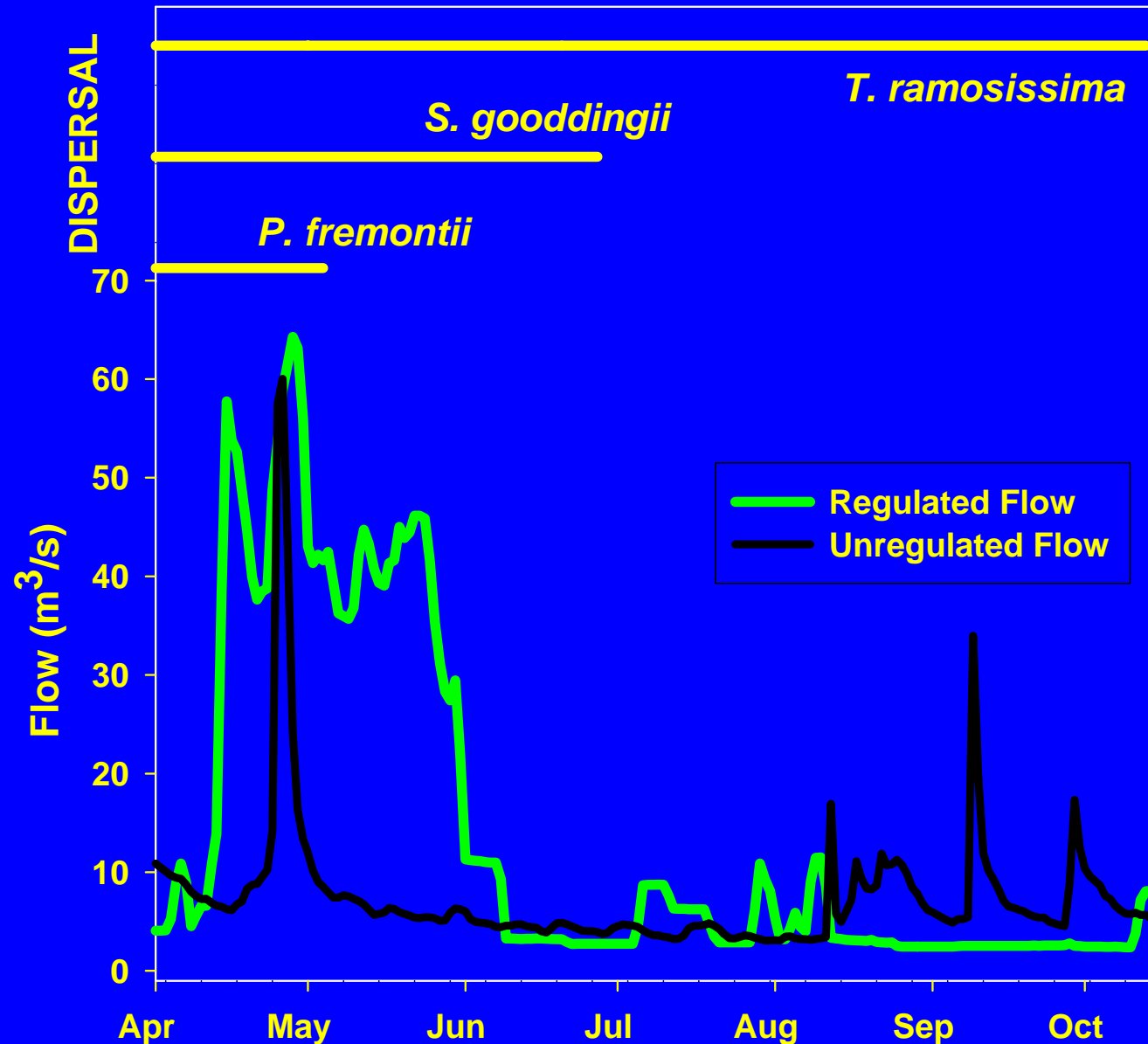


1995 Lower Verde Flow Regime

- Large spring floods and low summer flows should favor *P. fremontii* and *S. gooddingii*
- Extended late spring/early summer release may have provided increased opportunity for *T. ramosissima* recruitment



1995 April – September Flow



- Late spring/early summer release keeps banks inundated or groundwater levels elevated
- Flow recession in June provides moist areas for *T. ramosissima* and *S. gooddingii* recruitment

Conclusions – Woody Vegetation

- Localized recruitment of *Populus* and *Salix* is not affected
 - Large, relatively unmodified floods still occur periodically
 - High summer base flows alleviate drought stress
- *T. ramosissima* is denser in below dam reaches
 - Only more abundant in younger *Populus* stands
 - Probably due to release pattern after the 1995 spring flood
- These results apply at the stand level; at the landscape level, the extent of forest may be changing

Results - Herbaceous Vegetation

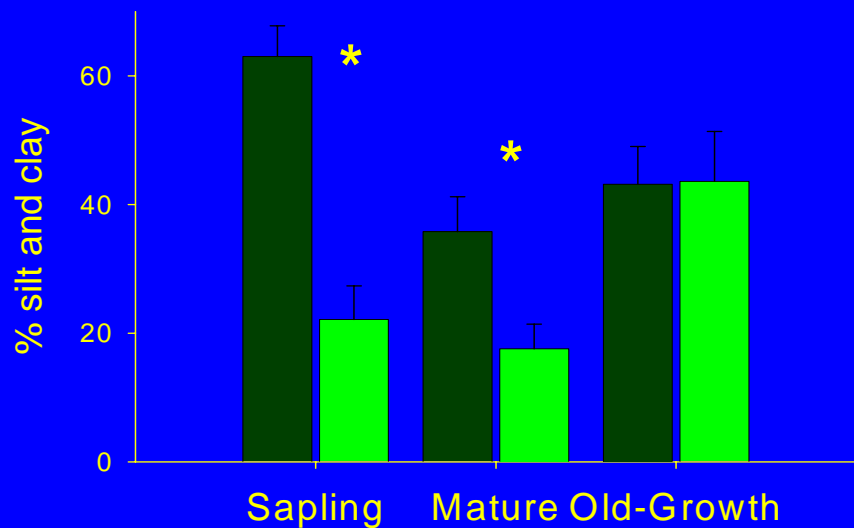
How does the herbaceous community of *Populus-Salix* stands differ between reach types?



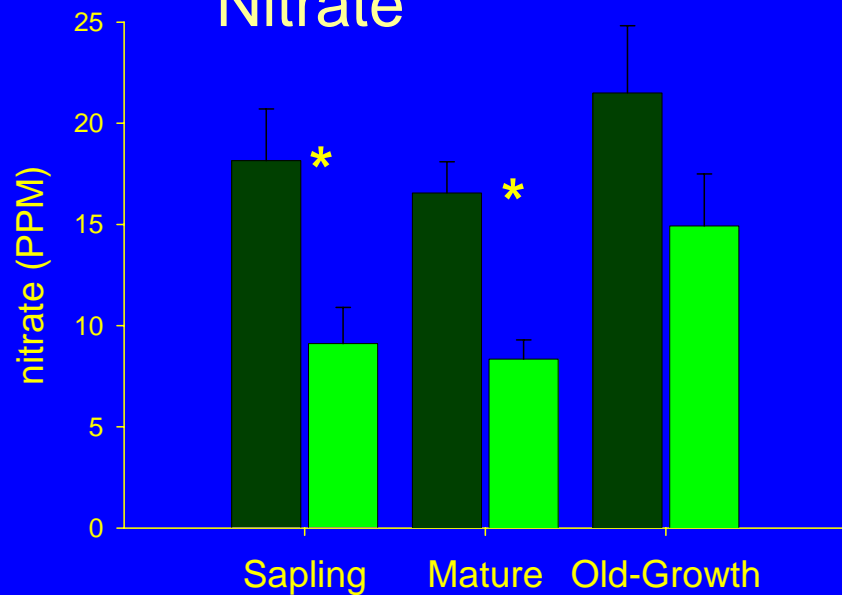
Hypotheses – Herbaceous Vegetation

- “Silt shadow” effect will decrease fine soils and nutrient concentrations below the dam
 - Herbaceous cover and richness will be lower in the regulated reach
- Decrease in flood frequency will create a more stable environment and allow for encroachment of upland species
 - Xeric and perennial species richness will be higher on the regulated reach (xerification)
- Alterations to the disturbance regime will favor exotic species
 - Exotic species richness will be higher in the regulated reach

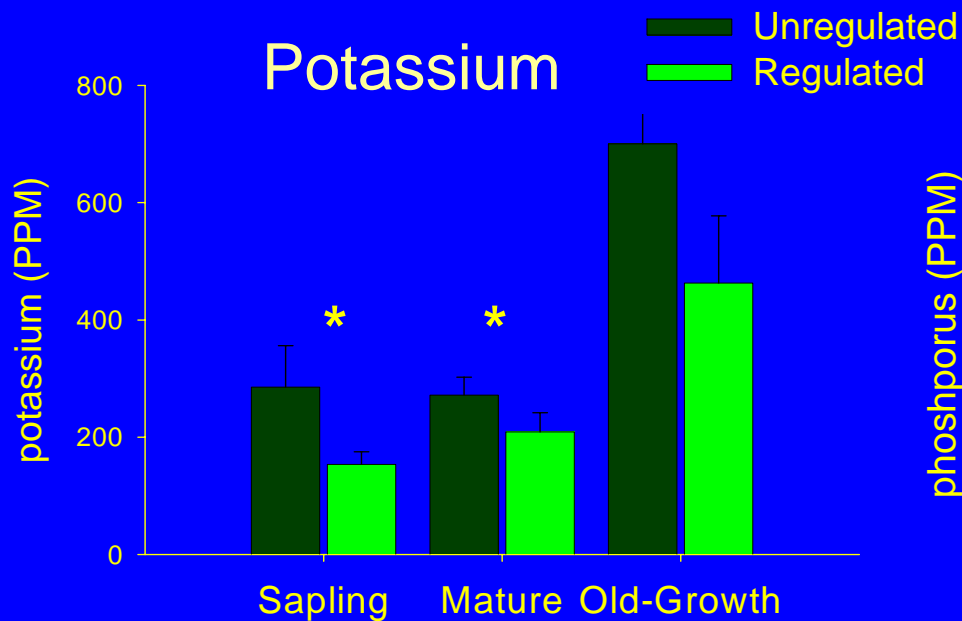
Fine textured soils



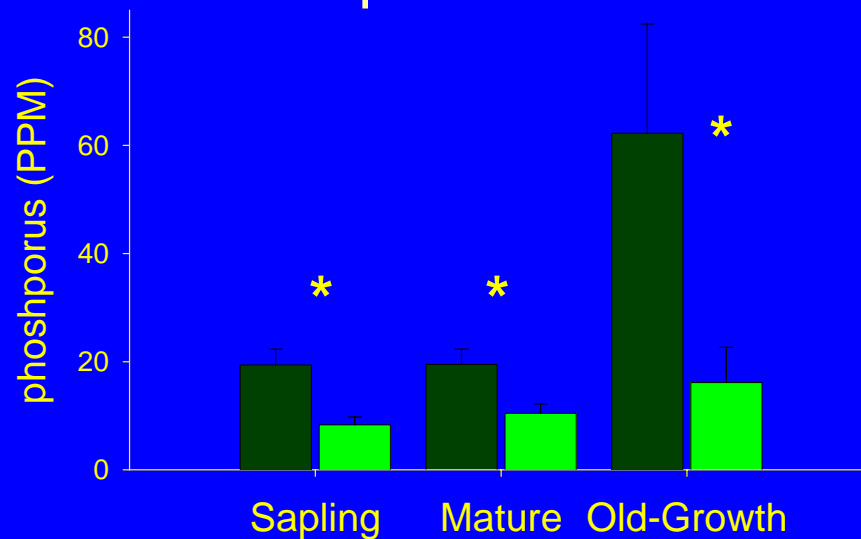
Nitrate



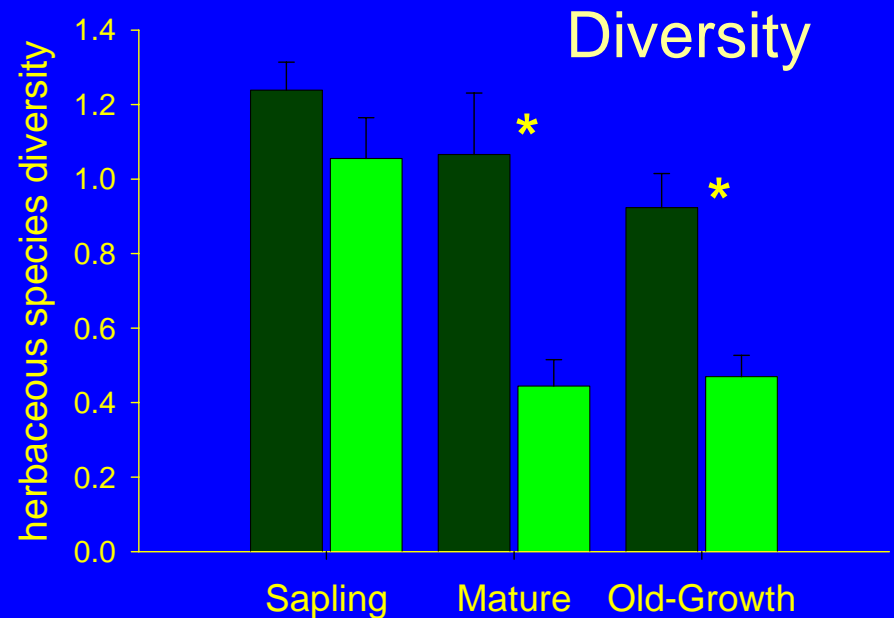
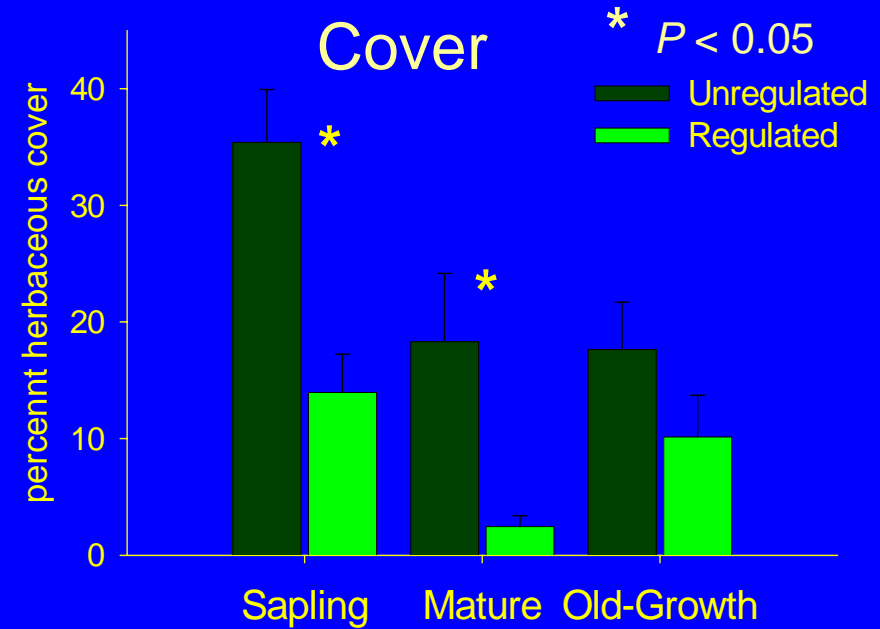
Potassium



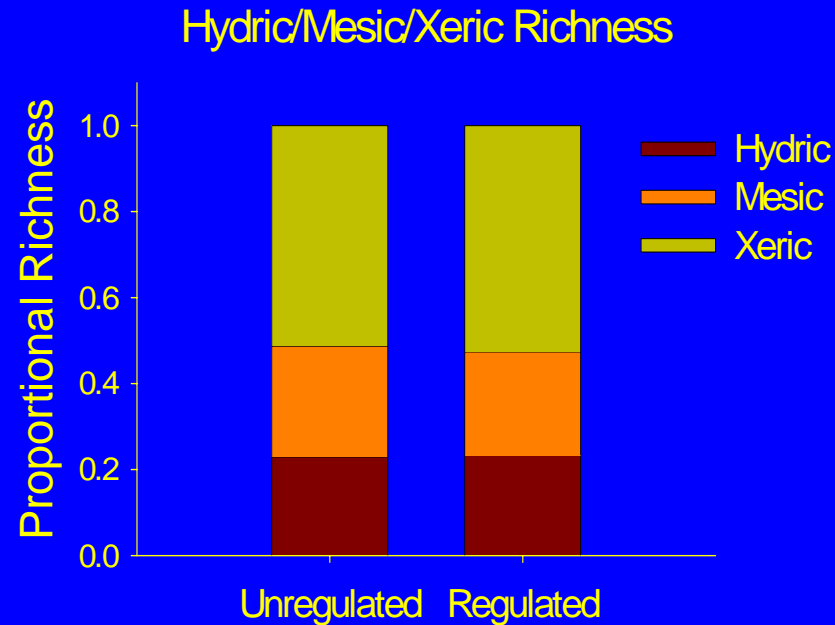
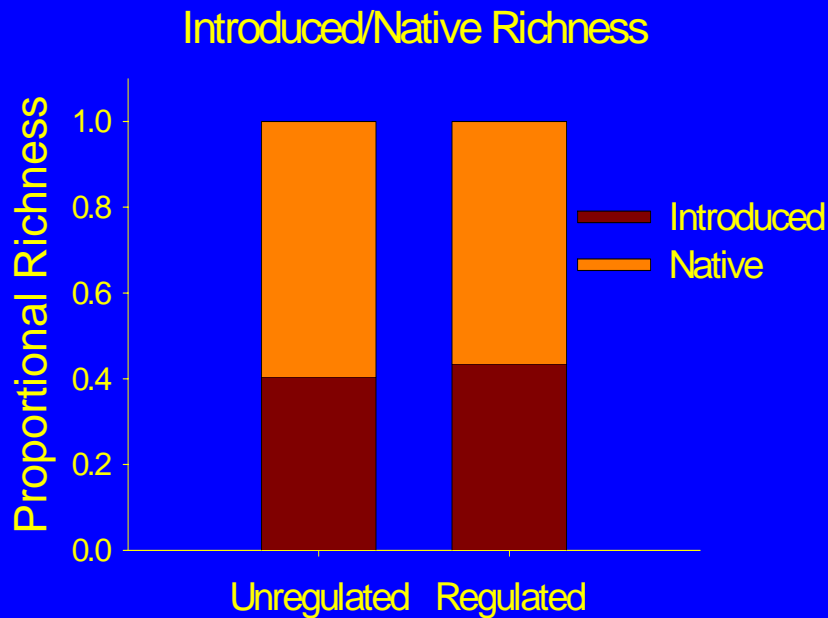
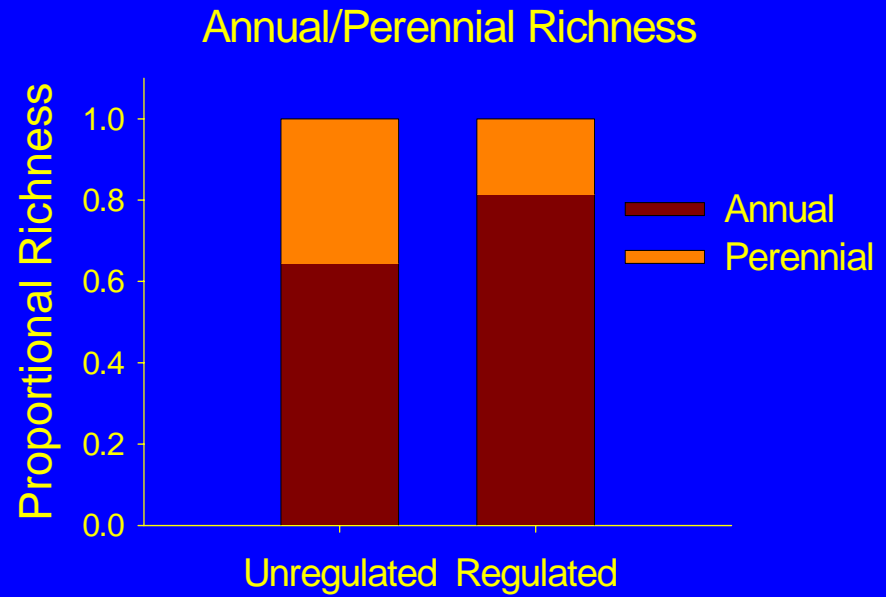
Phosphorus



- Averaged over four seasons cover, richness and diversity are lower in the regulated reach in most age classes



- Annual proportional species richness is higher in the regulated reach.
- Hydric, mesic and xeric proportional species richness are similar between reach types.
- Introduced and native proportional species richness are similar between reach types.



Conclusions – Herbaceous Vegetation

- Overall, herbaceous cover, richness and diversity are lower in the regulated reach.
- Regulated reaches have a higher proportion of annual species than unregulated reaches.
 - Due to stressful conditions created by reservoir sediment trapping and lack of flood borne sediment deposition.
- Xerification, increase in exotic species not occurring

Summary

- Woody vegetation structure at the stand level is similar between unregulated and regulated reaches
 - Large (<10 year R.I.) floods are relatively unaltered by reservoir operation.
 - Increase in *Tamarix* density in regulated sapling stands



Summary

- Woody vegetation structure at the stand level is similar between unregulated and regulated reaches
- Herbaceous vegetation cover and richness are lower in the regulated reach. Proportional annual species richness is higher.
 - Decreased fine soils and nutrients due to reservoir sediment trapping and lack of flood borne sediment deposition.



Conclusion

- The small reservoir capacity of the Verde system affects the flow regime on two scales
 - Large floods are relatively unaltered
 - Small floods, sediment and nutrients are trapped in the system
- The riparian ecosystem responds at two scales
 - Woody vegetation largely unaltered
 - Herbaceous vegetation affected



Acknowledgements

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