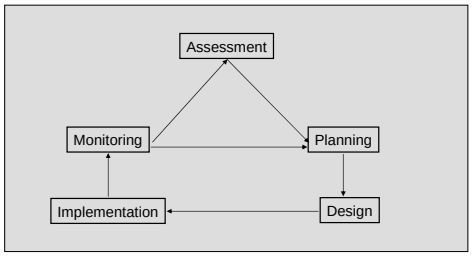
Research and Adaptive Management

Integral to all components
- Recognition of uncertainty
- Commitment to monitor and learn
- Willingness to adjust actions based on findings

Research and Adaptive Management



"learning to manage by managing to learn…"

Research Applications

- Assessment
  - Establish baseline conditions
  - Build guiding image from historical context
- Planning
  - Articulation of goals (no single fixed invariable endpoint)
- Design
  - Experiments testing effectiveness of techniques
  - Application of assessment & planning data
- Implementation
  - Logistical needs administration
- Monitoring
  - Species and/or community responses
  - Evaluation of goals

Conceptual Framework

- Multiple scales of interest
  - Organism
  - Reach
  - Corridor
  - Landscape
  - Watershed
- Research approaches may be scale dependent
  - Broader scales: ***descriptive*** and ***comparative*** approaches
  - Finer scales: integrate ***experimental*** techniques

Case studies

- Two examples at different scales
  - Invasive plants
    - Organism and community level effects
    - Reach scale: descriptive, comparative, experimental
  - Flow management
    - In-stream water supply as a function of land use
    - Landscape scale: descriptive, modeling

Taking aim at *Arundo*

Riparian Ecosystems: Vulnerable to Invasion

- frequent disturbance
- open space for colonization
- available nutrients
- available moisture

Plant Invaders & Riparian Systems

- changes in plant community composition and structure
- modification of aquatic plant and insect assemblages
- changes in stream temperature and dissolved oxygen levels
- influence on carbon availability

Giant Reed (*Arundo donax)*

- Native to Asia
- Clonal: no viable seed
- Native herbivore = elephant
- Fire adapted
- Water use
- Highly invasive
- Effects on biotic communities
- Limited research
- Large economic costs

Selected *Arundo* Research Questions

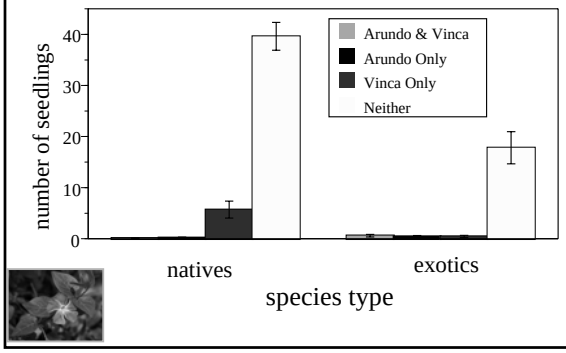
- Assessment & Planning
  - What are the effects of *Arundo* and *Vinca* on plant communities?
    - Native / exotic seedling abundance
  - What is the distribution of *Arundo* along the riparian corridor ?
- Design & Implementation
  - What are the most effective control methods for *Arundo?*
- Monitoring
  - Does seedling recruitment differ between treatments?

Giant Reed in the Russian River Watershed: infestation extent & type

Arundo infestation from the air

Main Stem – Alexander Valley

Number of Seedlings in *Arundo* and *Vinca* Invaded Habitats

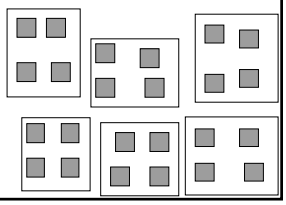


Removal Techniques

- Equipment removal
- Herbicide: cut and paint
- Hand removal
- Tarping
- Trade-offs: cost-effectiveness, environmental impact

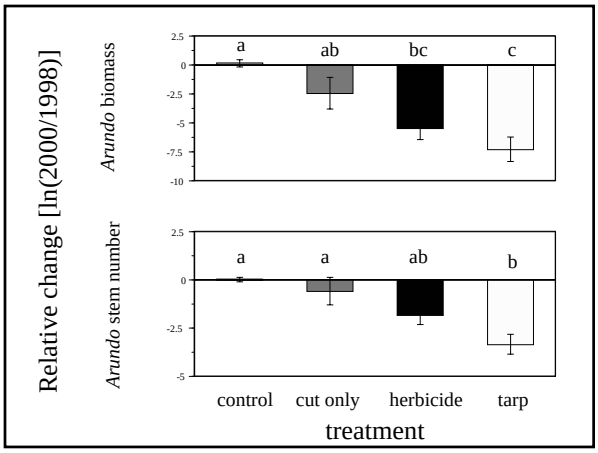
Experiment: *Arundo* Control Methods and Plant Community Effects

- Response variables
  - *Arundo* biomass
  - Plant Abundance: seedling -- native/exotic
- Treatments
  - Control
  - Repeated cutting and herbicide
  - Tarping
  - Repeated cutting
- Replication
  - 24 2 x 2 m plots
  - 6 blocks
  - 4 replicates

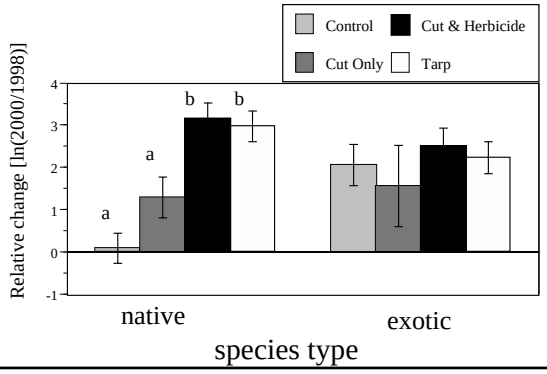


Assessing Effects Over Time

- Vegetation sampling:
  - prior to *Arundo* manipulation (Fall 1998)
  - 2 years after first manipulations (Summer 2000)
- tarp removed after one year (Fall 1999)
- cutting and herbicide continued through summer 2000
- Response variable:
  proportion change [ln(2000/1998)]



Post-treatment seedling abundance



Conclusions & Next Steps

Research Review
- *Descriptive mapping*
  - Arundo is widespread throughout watershed and distributed in clumps
- *Observational comparative study*
  - Seedling abundance in invaded habitats is low
- *Experimental manipulation*
  - Tarping may be more effective than cut & herbicide
  - No recruitment differences detected

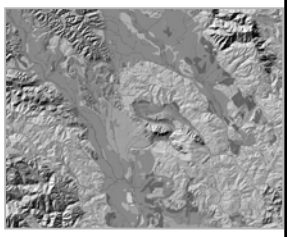
Planned research
- Energy use / environmental impact in different restoration designs
- More non-toxic effective control techniques
- Stem node viability and composting
- Active vs. passive revegetation

Modeling Landscape Factors to Improve Flow Management

Assessment of Landscape-scale Factors

- What factors outside the riparian zone are influencing aquatic and riparian habitat?
  - Land use
  - Water use

  } *Dramatic changes in California*
- Landscape scale
  - Descriptive research
  - "Secondary" research / modeling
- Applications
  - Improve understanding of broader scaled processes
  - i.e. River flow management

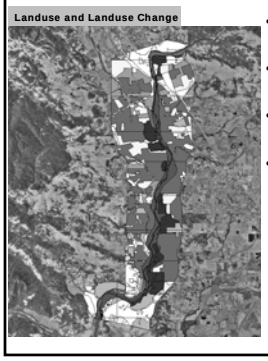


Russian River Healdsburg, CA

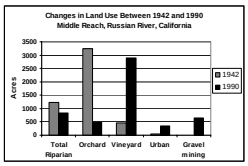
Project Setting: Russian River Watershed

- 3885 square kilometer basin
- Sonoma and Mendocino counties
- 95% of the Russian River watershed is in private ownership
- 34 fish species:
  - steelhead, coho, chinook are federally-listed
- Streamside landowners increasingly committed to preserving/restoring habitat
- Increased interest in collaboration between agencies, the community and landowners

Russian River Riparian Corridors

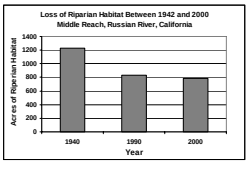


- High level of natural and human disturbance
- Dramatic land use changes similar to many coastal California communities
- Agricultural conversions
  - Orchard > Vineyard
- Urban growth



Russian River Riparian Corridors

1942 Riparian Habitat
1990 Riparian Habitat
2000 Riparian Habitat



Russian River Hydrology

- 110 mile long mainstem, 2 large dams
  - Potter Valley diversion from Eel
  - Flow regime change, esp. low / summer
- Flow management issues
  - Salmonid recovery planning
  - Urban/residential supply, growth, flooding
  - Agriculture
  - Recreation and tourism
- Sonoma County Water Agency
  - RR conduit -- water delivery to North Bay
  - SWRCB Decision 1610 -- minimum flow compliance points govern releases from dams
  - Many depletions occur along long sections between dams and compliance points
  - Avoid violations by extra releases

Warm Springs Dam (1975), Lake Sonoma

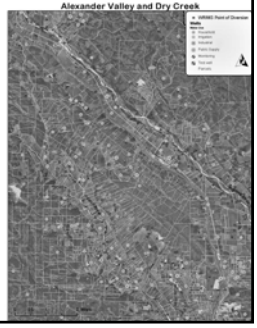
Coyote Dam (1958), Lake Mendocino

Water Use Variation and Magnitude

- Largest unknown depletions associated with vineyards (90% of basin agriculture)
- Irrigation: high spatial & temporal variability
  - Soil moisture capacity
  - Start date / annual weather differences
  - Practices: regulated deficit irrigation
  - Application rates and consistency
- Current model cannot explicitly account for this variation
- How big are potential irrigation diversions compared to the magnitude of minimum instream flows?
  - If large, better data can improve predictive understanding for more precise management

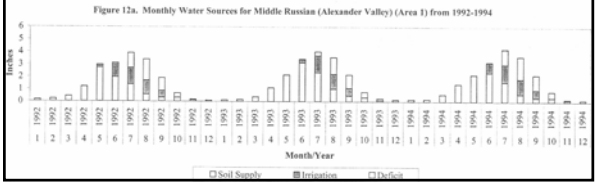
Land and Water Use Modeling

- GIS map inputs
  - Land use (parcels)
    - Where are the vineyards?
  - Soil types (NRCS)
    - What are the moisture characteristics?
  - CIMIS station data (precip, temp, ET)
    - What are evapotranspiration rates?
  - Water rights zones
    - Where are riparian, appropriative rights?
- Agricultural data
  - Crop coefficients
    - How much water can vines use?
  - RDI, start dates
    - What are amounts of intentional deficit?



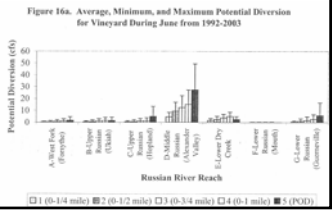
Land and Water Use Modeling

- Data input to standard computation of potential crop water use
- Bars indicate total potential ET on monthly basis
  - Soil + irrigation = actual ET
  - Plants are using full potential from Jan – June
  - Deficit irrigation occurs from July – Oct or Nov.



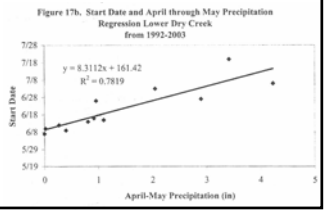
Model Results

- Total diversions summed by reach using predicted irrigation amounts
- How big are irrigation diversions relative to minimum instream flows?
  - Minimum instream flows range from 25 – 125 cfs
  - Irrigation diversions are potentially >100% of minimum instream flows during dry conditions
  - Highly uncertain in June and July
  - Start date accounts for much of this variability



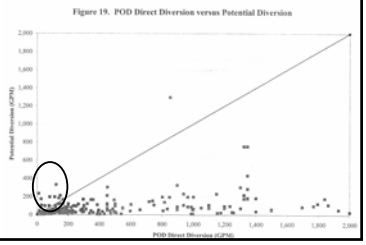
Model Application

- Predictability of irrigation start dates
  - June/July variability can be reduced if start dates are known
  - Each reach has unique soil characteristics and microclimates
- Late season precipitation explains 69-80% of the variation in start date
- Simple regression equations can assist flow management team predict start dates by reach



Model Application

- How does potential irrigation compare with permitted amounts?
  - Caution! model limits…
  - For each water right with permitted diversion rate, demands were calculated for July (peak irrigation)
  - Permitted diversions < 150 gpm, potential rate frequently exceeds permitted rate
  - Most larger permitted rates are well above potential
    - Cropping changes



Conclusions and Next Steps

Research review

- Descriptive data were modeled to simulate monthly irrigation demands
- Better info could improve flow management precision because the depletions are large relative to targeted flow requirements
- Late season precip is key factor
- Some small permitted water rights may be overextended but most are not

Future directions

- Examine finer spatial and temporal scales
- Calibrate model predictions with field plot data

Research Approaches

- Research approaches are scale dependent
- Type of question should match with appropriate research technique
  - Who, what, where, when, how?
  - Do groups differ?
  - Is there a cause-and-effect relationship?
- Research is integral to adaptive management
- Learn to manage by managing to learn…