Prescribed Herbivory for Fire Fuels Management

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Background

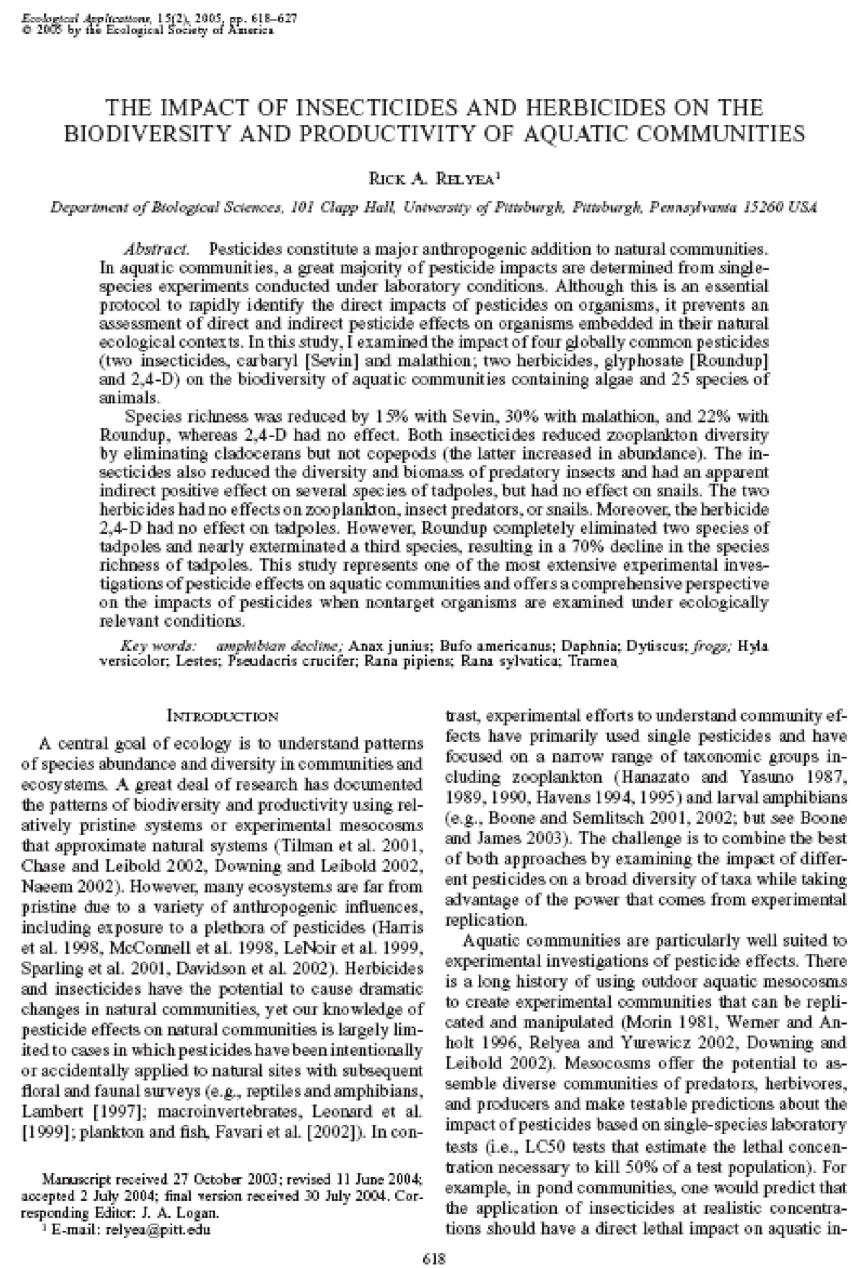
- The website address of the CA department of forestry is *fire.ca.gov*
- This is an adequate description of the sphere in which fire fuel management takes place
- There is a lot of confusion about how much money is spent on fire fighting vs. on fire prevention, but long-term averages for fire fighting are somewhere around 100 mio $/year

Traditional tools are becoming more limited:

Prescribed fire: air quality, risk management, cost

Herbicides: environmental impact under scrutiny (see right)

Mechanical clearing: very costly and requires integration with other methods



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THE IMPACT OF INSECTICIDES AND HERBICIDES ON THE BIODIVERSITY AND PRODUCTIVITY OF AQUATIC COMMUNITIES

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Abstract. Pesticides constitute a major anthropogenic addition to natural communities. In aquatic communities, a great majority of pesticide impacts are determined from single-species experiments conducted under laboratory conditions. Although this is an essential protocol to rapidly identify the direct impacts of pesticides on organisms, it prevents an assessment of direct and indirect pesticide effects on organisms embedded in their natural ecological contexts. In this study, I examined the impact of four globally common pesticides (two insecticides, carbaryl [Sevin] and malathion; two herbicides, glyphosate [Roundup] and 2,4-D) on the biodiversity of aquatic communities containing algae and 25 species of animals.

Species richness was reduced by 15% with Sevin, 30% with malathion, and 22% with Roundup, whereas 2,4-D had no effect. Both insecticides reduced zooplankton diversity by eliminating cladocerans but not copepods (the latter increased in abundance). The insecticides also reduced the diversity and biomass of predatory insects and had an apparent indirect positive effect on several species of tadpoles, but had no effect on snails. The two herbicides had no effects on zooplankton, insect predators, or snails. Moreover, the herbicide 2,4-D had no effect on tadpoles. However, Roundup completely eliminated two species of tadpoles and nearly exterminated a third species, resulting in a 70% decline in the species richness of tadpoles. This study represents one of the most extensive experimental investigations of pesticide effects on aquatic communities and offers a comprehensive perspective on the impacts of pesticides when nontarget organisms are examined under ecologically relevant conditions.

Key words: *amphibian decline;* Anax junius; Bufo americanus; Daphnia; Dytiscus; *frogs;* Hyla versicolor; Lestes; Pseudacris crucifer; Rana pipiens; Rana sylvatica; Tramea

INTRODUCTION

A central goal of ecology is to understand patterns of species abundance and diversity in communities and ecosystems. A great deal of research has documented the patterns of biodiversity and productivity using relatively pristine systems or experimental mesocosms that approximate natural systems (Tilman et al. 2001, Chase and Leibold 2002, Downing and Leibold 2002, Naeem 2002). However, many ecosystems are far from pristine due to a variety of anthropogenic influences, including exposure to a plethora of pesticides (Harris et al. 1998, McConnell et al. 1998, LeNoir et al. 1999, Sparling et al. 2001, Davidson et al. 2002). Herbicides and insecticides have the potential to cause dramatic changes in natural communities, yet our knowledge of pesticide effects on natural communities is largely limited to cases in which pesticides have been intentionally or accidentally applied to natural sites with subsequent floral and faunal surveys (e.g., reptiles and amphibians, Lambert [1997]; macroinvertebrates, Leonard et al. [1999]; plankton and fish, Favari et al. [2002]). In contrast, experimental efforts to understand community effects have primarily used single pesticides and have focused on a narrow range of taxonomic groups including zooplankton (Hanazato and Yasuno 1987, 1989, 1990, Havens 1994, 1995) and larval amphibians (e.g., Boone and Semlitsch 2001, 2002; but *see* Boone and James 2003). The challenge is to combine the best of both approaches by examining the impact of different pesticides on a broad diversity of taxa while taking advantage of the power that comes from experimental replication.

Aquatic communities are particularly well suited to experimental investigations of pesticide effects. There is a long history of using outdoor aquatic mesocosms to create experimental communities that can be replicated and manipulated (Morin 1981, Werner and Anholt 1996, Relyea and Yurewicz 2002, Downing and Leibold 2002). Mesocosms offer the potential to assemble diverse communities of predators, herbivores, and producers and make testable predictions about the impact of pesticides based on single-species laboratory tests (i.e., LC50 tests that estimate the lethal concentration necessary to kill 50% of a test population). For example, in pond communities, one would predict that the application of insecticides at realistic concentrations should have a direct lethal impact on aquatic in-

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Background

- The amount of money spent on prevention is definitely much lower but there are no consistent figures
- CDF cost recovery money intended to go into VMP has been consistently diverted into the general budget, if collected at all
- The current situation seems to be heavily influenced by a 'fire-fighting industry' vs. emphasis supporting community responsibility

Background

- Fuel reduction via prescribed herbivory is now an acceptable tool in fire safe plans
- A lot of interest, several operators in action (some better than others) and a near-total lack of information about:

Background

- Management protocol
  - Nutrition
  - Health
  - Strategic supplementation
  - Stocking rates
  - Realistic impact objectives
- Impact assessment
- Effects on plant community dynamics
- Effects on invasibility
- Effects on soil, sediment movement
- Cost of herbivory vs. other tools


Prescribed burn west of Red Bluff, 2006

Background - Tools

- Mechanical: essential tool, very costly, needs fire
- Herbicides: increasingly problematic, needs fire
- Prescribed fire: increasingly problematic, costly, increasingly narrower time windows

Background

- Exploding interest in herbivory
- Several operators
- Long-standing practice
- Heuristic knowledge but zero data
- EIS generally avoided, especially when applied in context of fire-safe operations due to questionable ‘blanket’ exemptions

Background

- UCCE has supported the idea in several ways, most notably by the California Browsing Academy
- Extension work highlights research needs, but funding *extremely* difficult – no commodity groups, and often die-hard opposition by anti-grazing coalitions

Basic Research Needs

- Impact of vegetation on animals:
  - Health and performance (determines operation cost)
- Impact of animals on plants (comparative efficacy and cost)
- Impact of animals on soil and wildlife

The concept is old

- Herbivory is an old practice in CA, but it was ad hoc rather than prescribed and so there are few data
- Previous authors have researched nutritional and anti-nutritional properties of CA Chaparral belt brush species, but results ranged from questionable to wrong due to inadequate methods

The concept is old

- The Mediterranean Basin and several other areas around the world (Canary Islands, SE Australia) are testimony to the effects of removal of browsing domestic herbivores – explosive growth in wildfire frequency and severity
- So we know it works, but (a) does it work they way it should, and (b) what does it take to turn it into a service

Isla Santiago in the Galapagos Islands – 90,000 goats on a rampage

Unprescribed near-total vegetation management

Research Program Priority 1

- Determine nutritional and anti-nutritional properties of target species
  - How much will they eat?
  - Can we maintain condition and performance (i.p. reproduction) ?
  - How much will it cost to deliver the service?
  - Will we be cited for animal care violations?
  - Do we need supplementation and what is the best type of supplementation?

Previous work vs. current results

Species	Season[1]	ASH	CP[2]	Tannins/SCT[3]	IVDMD[4]	IVDOM[5]
A. fasciculatum	Summer	4.2	10.5		28.5	
	All seasons	2.8	5.44	4.21		28.3
A. fasciculatum	Spring	2.9	5.38	7.49		36.43
	Summer	2.65	3.63	4.74		34.63
	Fall	2.42	4.09			36.32
A. glandulosa	Summer	3.9	6.7		28.4	
	All seasons	3.26	5.31	***0***		30.2
A. glandulosa	Spring	2.68	3.99	**19.97**		37.71
	Summer	4.3	3.85			37.19

Shaded: Sidahmed et al (UC Davis work); unshaded: our lab results
1 All seasons = mix of samples collected in every season; 2 Crude Protein (%);
3 Estimated condensed tannins (ADF –NAD) OR soluble condensed tannins (%); 4 *In vitro* Digestibility of Dry Matter – Tilley and Terry, 1963 (%); 5 *In vitro* Digestibility of Organic Matter (Predictive equation based on chemical constituents) (%)

Note: our lab used for this comparison total plant samples (like Sidahmed). However, this approach does not provide meaningful results.

Important Results

- All 10 brush species comprehensively assayed so far (monthly collections for one year) have
  - Moderate to extreme levels of PSM (focus on tannins so far)
  - Nutrient content too low for maintaining condition

Important Results

- The chemistry of tannins encountered is so complex that comprehensive GC-MS discovery work is needed for progress (will be conducted in the UCD Genomics Facility)
- Further work on diet selection and strategic and tactical supplementation is needed (for example, we could achieve maintenance performance on 100% manzanita with PEG supplementation alone)

Tannin Chemistry (leaves)

Species	Season	SCT	ICT	TCT	CR
A. canescens	Fall	31.29	17.93	49.23	14.17
	Spring	34.54	20.58	55.12	12.50
	Summer	27.36	16.61	43.97	14.59
C. cuneatus	Fall	31.76	13.89	45.65	6.95
	Spring	26.30	20.02	46.32	5.73
	Summer	26.51	15.96	42.47	6.18

Current Field Focus

- First large scale, landscape treatment project with prescribed herbivory in CA: Sunflower CRMP in Red Bluff

First Practical Conclusions

- Economically sustainable use of prescribed herbivory can occur on:
  - Maintenance grazing of fuel breaks with mixed goat-sheep flocks
  - High impact browsing where burns are not possible (high cost service)
  - Specialized impact browsing in timber plantations (medium/high cost service)
  - Follow-up on burned areas (short term)

First Practical Conclusions

- There is considerable dynamic change in nutrient content in each brush species throughout the year, and not all species are aligned on the time axis
- This explains variation in diet selection, which must be further studied
- Supplementation requirements are highly variable and high specific and require site and application specific recommendations