

# *Allelochemical behavior in soil environments*

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# Russian knapweed

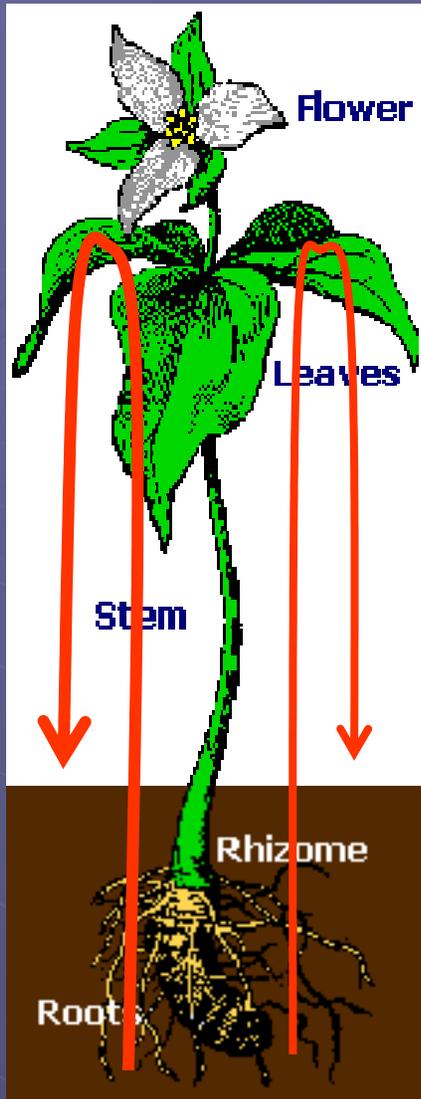
(*Acroptilon repens*)

- Currently a noxious weed in 14 states
- Most persistent of all knapweeds
- Russian knapweed first arrived in North America around 1898
- Contaminant of imported Turkestan alfalfa seed
- Russian knapweed is a creeping perennial and spreads aggressively by vegetative means forming monocultures

- Notoriously difficult to control due to the extensive root system
- Currently, the most successful way to treat RK is to use 2,4-D and Clopyralid and then revegetate the area with fast growing, vigorous grasses

# Allelopathy

- Refers to chemical interactions between plants
- The release of phytotoxins by plants can have inhibitory or stimulatory effects on plants affected
- Russian knapweed has both elemental and organic allelopathic properties



## Phytoenrichment

Zone of zinc accumulation



# Russian knapweed induced Zn Allelopathy

## ● Christo Morris and Chris Call (USU)

- studied Russian knapweed to determine whether Zn allelopathy aides in the successful spread of RK in the West

## ● Soil was collected from Dinosaur National Monument, Utah

- soil Zn levels from the park were determined
- Zn phytotoxic levels for plant fatality were determined in a study conducted in a greenhouse

# Russian knapweed induced Zn Allelopathy

- Zn levels in the soil samples from Dinosaur park were lower than the worldwide mean for Zn levels in soil.
- However, Russian knapweed enhanced the bioavailability of Zn in underlying soils.
- The study failed to show if the higher levels of bioavailable Zn were enough to restrict the growth of other species.
- It was also unclear whether or not Russian knapweed is a true hyper accumulator of Zn.

# Greenhouse trial

## ● 4 plants

- Russian knapweed
- Alkali sacaton
- Bluebunch wheatgrass
- Russian wildrye

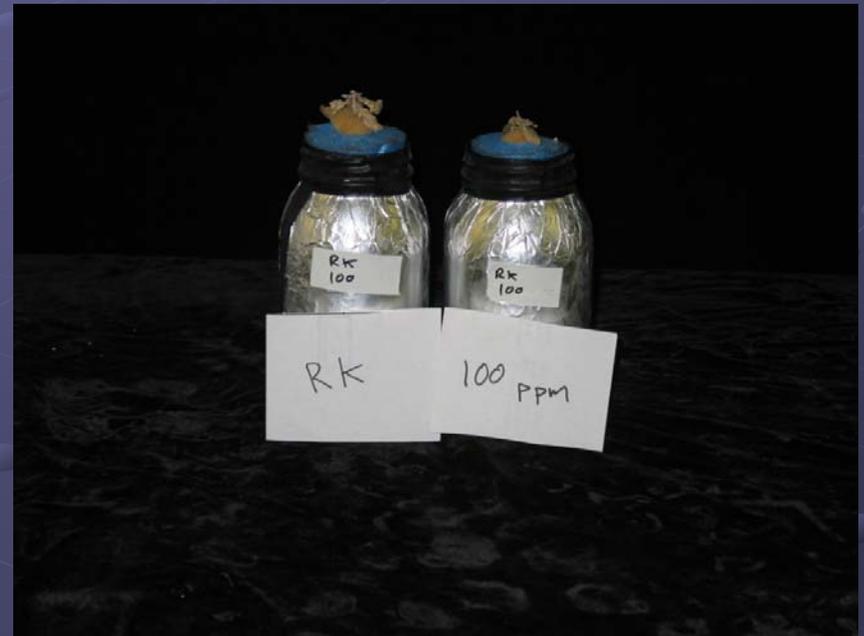
## ● 4 treatments (Zn concentrations in the nutrient solution)

- 0, 20, 50 and 100ppm

# Russian knapweed: 0 & 20ppm Zn



# Russian knapweed: 50 & 100ppm Zn



# Alkali sacaton at 0 and 20ppm Zn



# Initial results:

- RK appeared to resist Zn levels between 0 & 20ppm
- Grasses showed severe signs of stress at 20ppm Zn
- Zn concentrations in plant tissue still need to be determined – this will establish if RK is a Zn hyper accumulator

# Organic allelopathy

- Organic compounds
- Exudation of allelopathic chemicals from the plant roots into surrounding soil
- 7,8-benzoflavone from RK
  - Stermitz, F.R., H.P. Bais, T.A. Foderaro, and J.M. Vivanco. 2003. 7,8-Benzoflavone: a phytotoxin from root exudates of invasive Russian knapweed. *Phytochemistry* 64:493-497.
- (-)-catechin from Spotted Knapweed
  - Bais, H.P., R. Vepachedu, S. Gilroy, R.M. Callaway, and J.M. Vivanco. 2003. Allelopathy and exotic plant invasion: From molecules and genes to species interactions. *Science* 301:1377-1380.

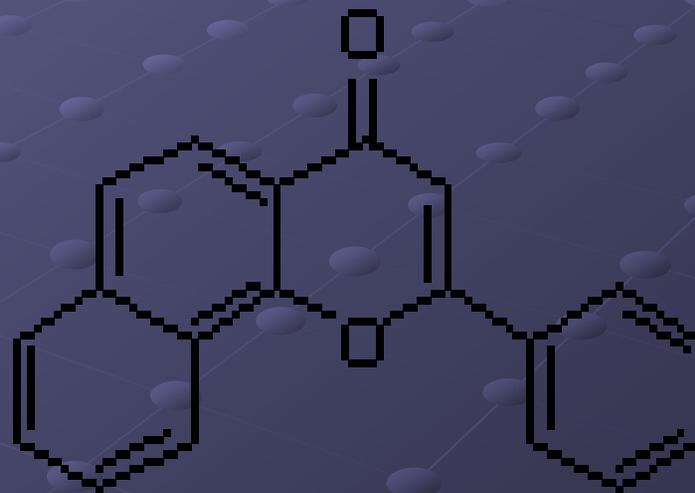
# Chemical structure of 7,8-Benzoflavone

●  $\alpha$ -Naphthoflavone  
( $\alpha$ -Naphthoflavone)

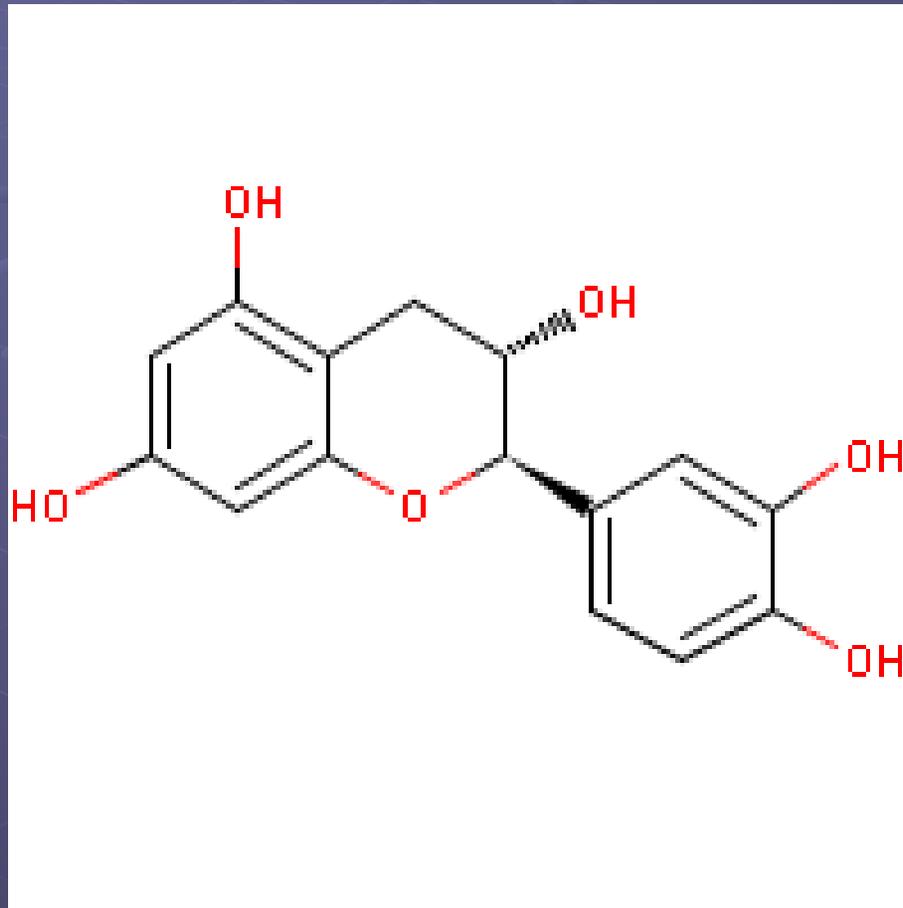
● Molecular Formula



● Molecular Weight



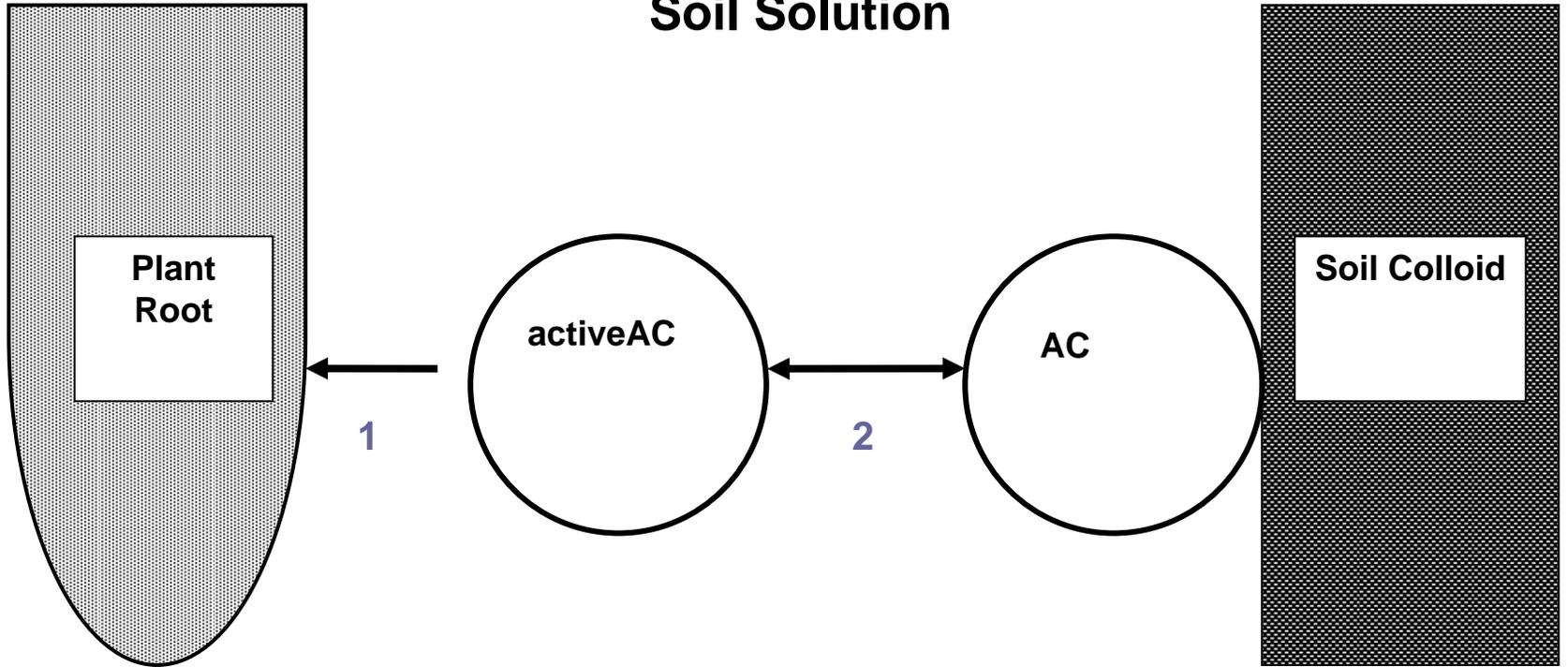
# (-)- catechin





**Russian knapweed at field site in Dinosaur Nat. Mon., UT.**

# Soil Solution



## ● Determine how soil properties influence the bioavailability organic allelochemicals?

- 7,8-Benzoflavone may sorb to soil constituents such as Fe-oxides, organic matter, and clays. Sorption can also be influenced by soil pH.
- Understanding the conditions resulting in optimum sorption could help prevent further spread of RK and SK.

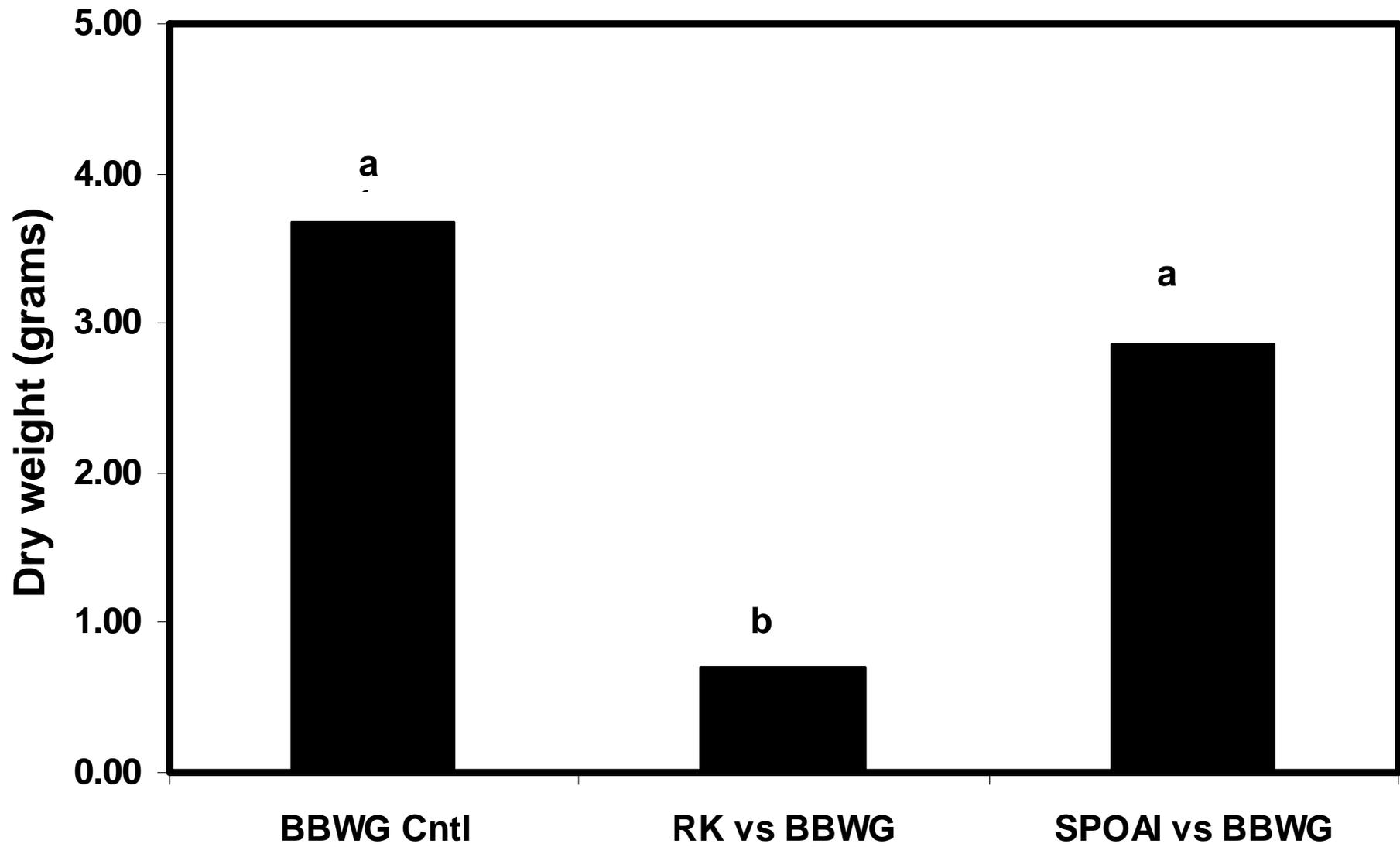
# Greenhouse/Hydroponic phytotoxicity study

*S. airoides* vs. *P. spicata*

*S. airoides* vs. *A. repens*

*P. spicata* vs. *A. repens*

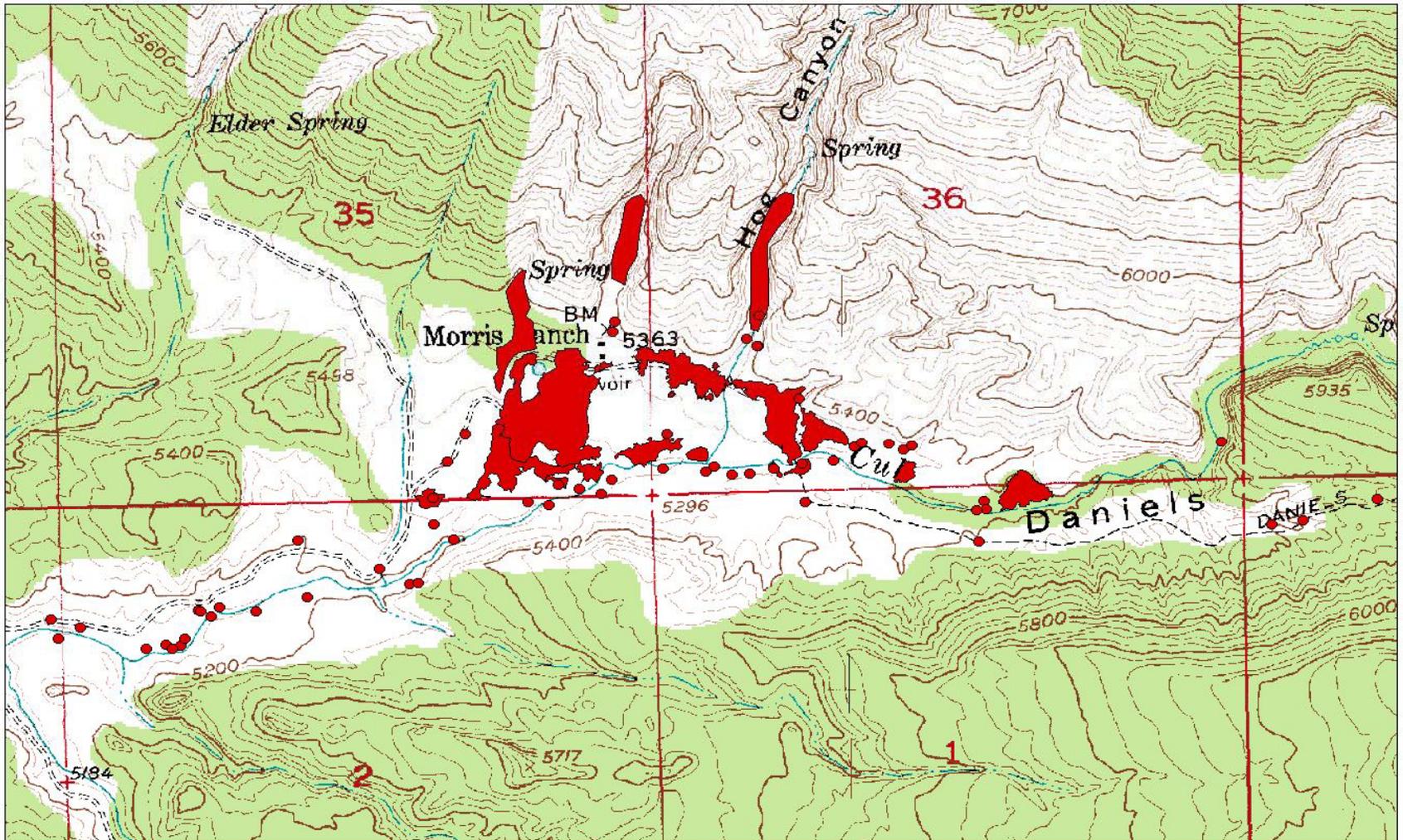
Control for each species



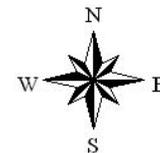
# Russian knapweed & soil properties

- Russian knapweed is more prevalent in a finely textured soil
  - Possibly due to higher water holding capacity of clay soils
  - Finer soil would hold, concentrate, and expose roots to soil solutions for longer time periods
  - 7,8-Benzoflavone would be in solution under Russian knapweed stands

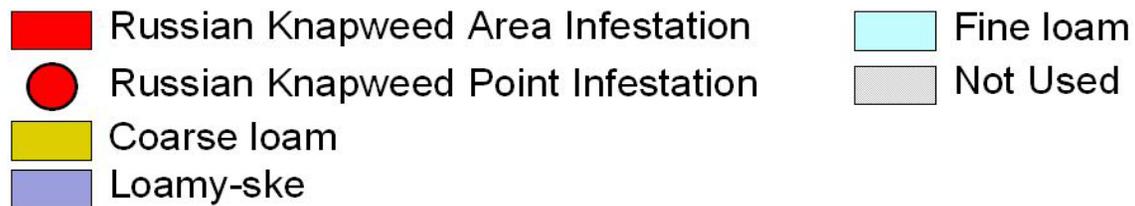
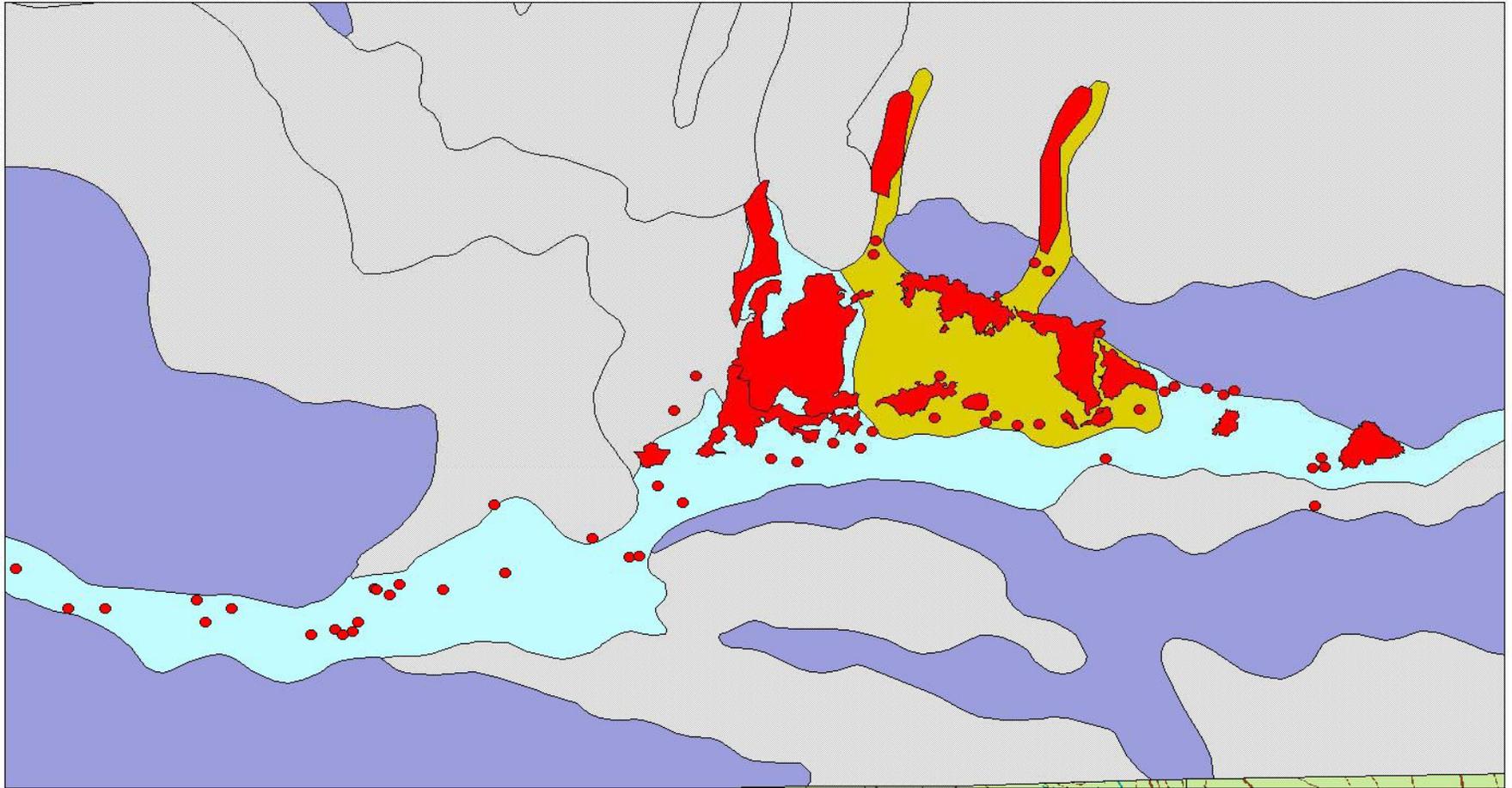
# Russian Knapweed Infestations Morris Ranch



- Russian Knapweed Point Infestation
- Russian Knapweed Area Infestation

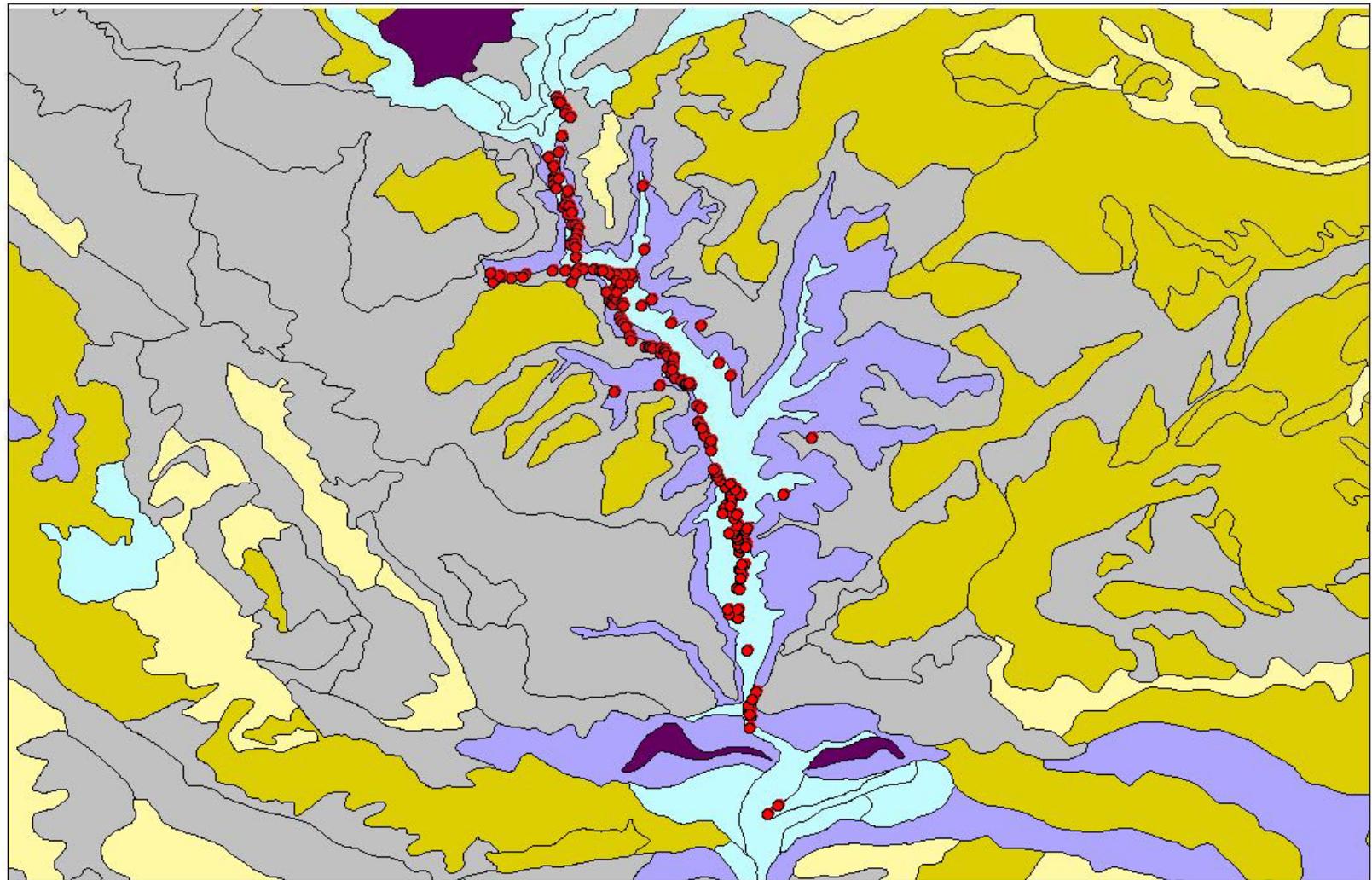


# Morris Ranch Soil Texture Map



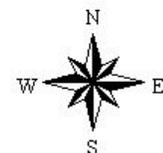


# Arches National Park: Salt Wash



- Russian Knapweed Point Infestation
- Fine Silt
- Coarse Loam
- Not Used

- Loamy-Ske
- Loam
- Fine Loam





# Elemental allelopathy in Russian knapweed

- Litter from perennial plants which are metal hyperaccumulating, leaches into the soil beneath the plant
- The litter is laden with potentially toxic metals
- These metals inhibit the establishment of other less metal-tolerant plant species
- Zn is hyperaccumulated by RK