# Impacts of Fire Ecology Range Management on the Fate and Transport of Energetic Materials on Testing and Training Ranges

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# Performers

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- **Role: Principal Investigators**

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- **Role: Thermal Decomposition of Explosives**

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- **Role: Range Characterization**

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- **Role: Prescribed Burning**

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# Problem Statement

- A growing body of evidence suggests that hazardous energetic materials, such as nitroaromatics and nitramines, are accumulating in soil on DOD testing and training ranges.
- There is concern that the accumulation of energetic materials in soils will lead to groundwater and surface water contamination.
  - In fact, DOD training activities have been affected by groundwater contamination associated with ranges.
  - USEPA issued an administrative order that suspended training at the Massachusetts Military Reservation (MMR).
- Range management practices designed to mitigate or minimize the accumulation and off-site transport of these hazardous constituents are needed

# Project Conception

- Observation:
  - Prescribed burning is commonly used on ranges to control vegetation.

- Questions:
  - Does burning reduce the inventory of explosive residues on surface soils?
  - Can burns be designed to maximize explosive residual destruction?
  - Is there sufficient natural fuel to burn impact zones?
  - Do plants consumed in burns accumulate explosive residuals?
  - Does burning increase the mass flux of explosive residues in runoff?

# Background

Prescribed Burning

- Used for decades to achieve a variety of range management objectives including:
  - Fuel hazard reduction (wildfire control)
  - Improving accessibility (facilitates UXO clearance)
  - Invasive species management
- Specific objectives can be met by prescribing burn variables
  - Season
  - Fire type
    - backing fire: burns hotter at ground surface, better fuel consumption
    - heading fire: spreads faster, more smoke, cooler at ground surface
    - flanking fire: intermediate intensity and smoke generation
  - Weather conditions
    - wind, relative humidity, temperature, precipitation, soil moisture, atmospheric stability
  - Fuel condition/load

# Background

Thermal Decomposition of Explosives

- Considerable research has been done on the thermal decomposition of neat explosives
  - 5 second explosion temperature (0.2 mg)
    - RDX: 260 °C
    - HMX: 327 °C
    - TNT: 475 °C
- The rate of thermal decomposition of explosives is a function of:
  - temperature
  - matrix (pure, in solution, presence of other chemicals)
  - concentration
- Little information is available about the thermal decomposition of soil-associated explosive residues at elevated temperatures.

# Background

Phytoextraction of Explosives

- Numerous studies have evidenced the ability of various aquatic and terrestrial plant species to uptake and transform TNT
  - TNT and transformation products (2-ADNT, 4-ADNT) found in the root structure; the stem and leaves do not appear to be reservoirs
- Other studies have shown the translocation of RDX and HMX in plants; distributed primarily into plant shoots
- Our primary concerns:
  - Is it happening on the range?
  - If so, can it be optimized?
- Coordination/cooperation with other SERDP researchers/projects

# Technical Objectives

- Determine the depth to which burning provides effective decomposition of energetic residuals. (decomposition as a function of temperature)
- Examine relationship between energetic residuals and vegetation density (fuel load).
- Determine if native plant species accumulate energetic compounds and if so, how those compounds are distributed within the plant.
- Determine impact burning has on mass loading of energetic compounds in runoff.

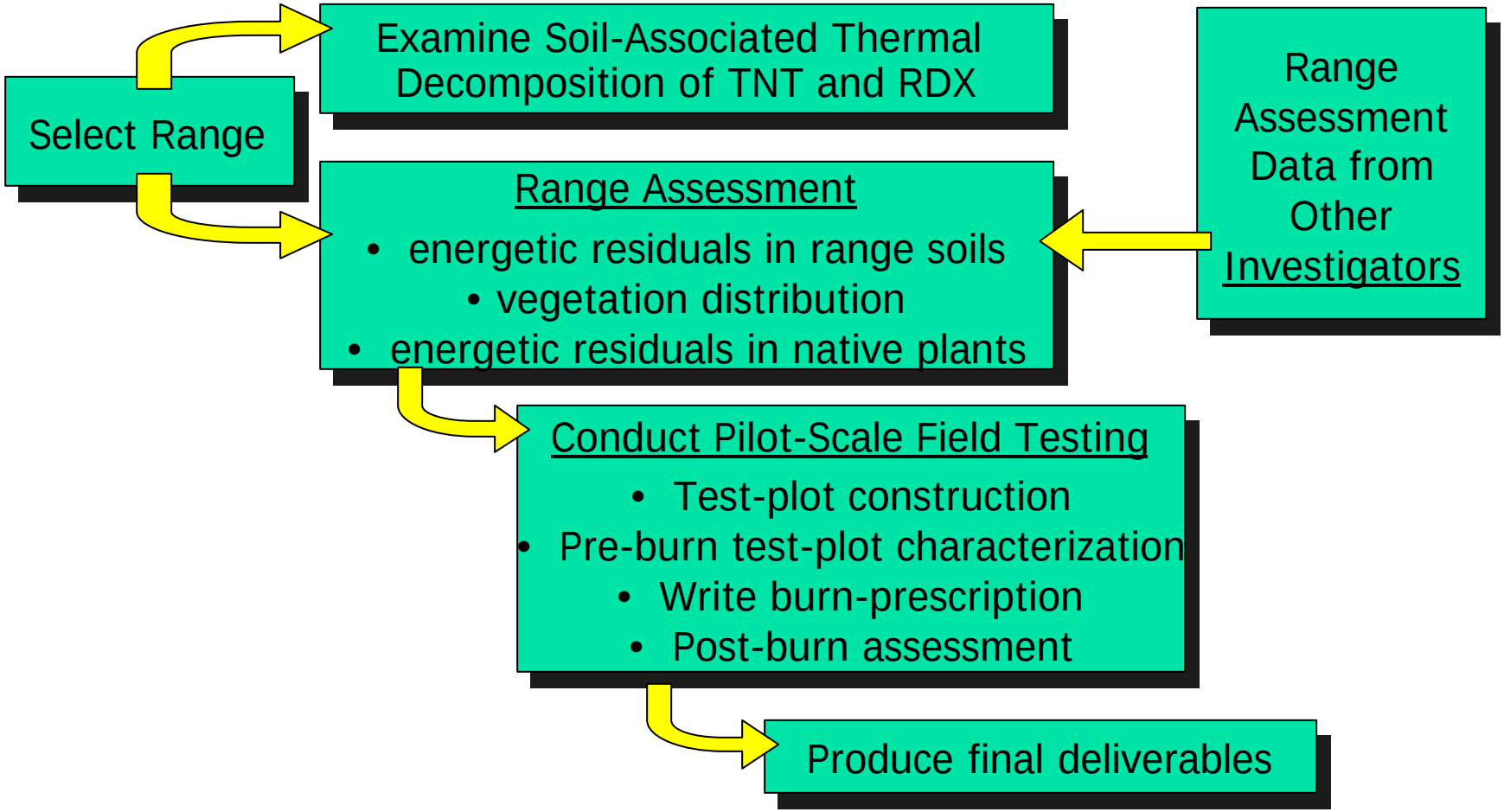
# Study Design

- Laboratory Study at the University of Rhode Island
  - Examine the thermal decomposition of soil-associated TNT and RDX

- Field Investigations on Selected Range
  - Range Assessment
    - Spatial distribution of energetics in soils
    - Spatial distribution of range vegetation
    - Phytoextraction of energetics
  - Pilot-Scale Burn
    - Measure change in energetic inventory
    - Examine change in mass flux of energetics in run-off

# Technical Approach

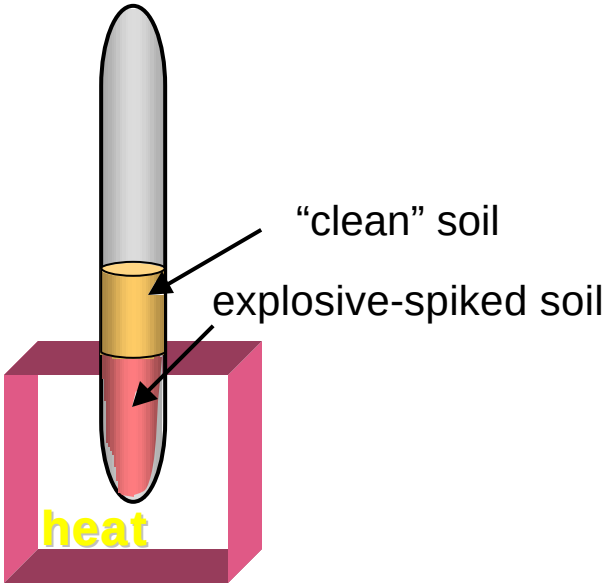
## Overview



# Technical Approach

**Soil-Associated Thermal Decomposition Study**

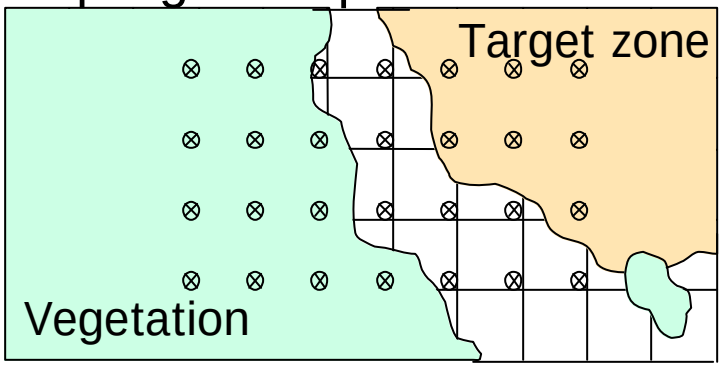
- Bench-scale study designed to examine the thermal decomposition of TNT and RDX
- Experiments will be conducted with soils collected from the selected range
- Soils will be heated under the following experimental conditions:
  - temperature range:  200-350 °C
  - explosive concentration range: 0.1% to 10%
  - soil moisture content 0-10%
- Samples will be analyzed to determine
  - decomposition rate of explosive
  - migration of explosive away from heat
  - analyze products in off-gas
- Unheated controls will be run to account for losses due to sequestration



# Technical Approach

## Range Assessment

Sampling for explosive residuals




Sampling plan will be developed that accounts for high level of heterogeneity. It will build upon work and experiences of Jenkins et. al.

Examine Vegetation Distribution

Visual surveys and aerial photographs (if available)

# Technical Approach

## Range Assessment

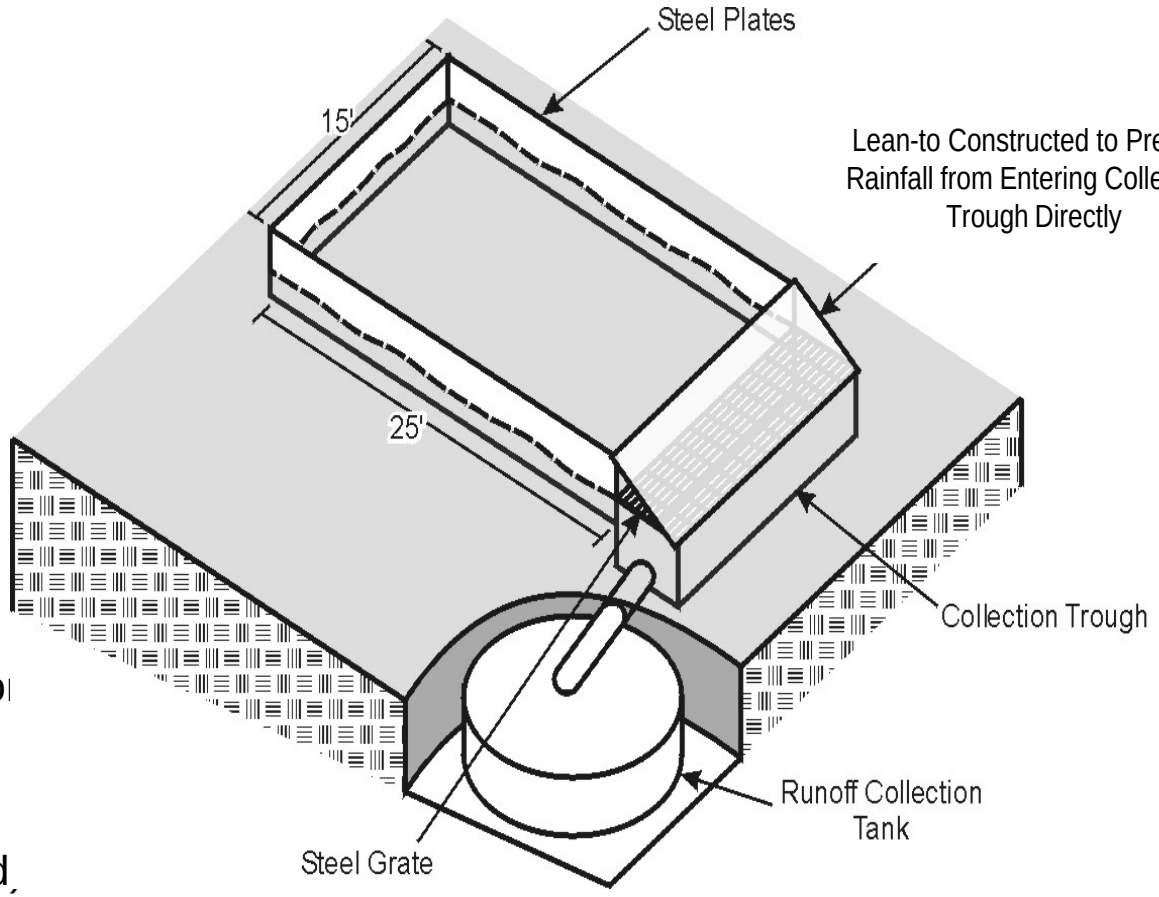
Plant sampling for explosive residuals

- Collect plant tissue samples
- Correlate soil and plant sampling locations so relationship between uptake and soil concentration may be examined
- Analyze extracted samples for nitroaromatics and nitramines

# Technical Approach

## Pilot-Scale Field Testing

- Construct 6 test plots
  - 3 treatment plots
  - 3 control plots
- Instrumentation
  - thermocouples
  - down-gradient collection trough
  - 650-gal plastic collection tank
- Characterize plots
  - energetic residuals
  - grain-size distributio
  - organic matter
  - runoff calibration
  - vegetation (fuel load



# Technical Approach

## Pilot-Scale Field Testing

- Write fire prescription
- Conduct burn
- Post-burn assessment
  - explosive residuals
    - soil
    - runoff
    - sediment
  - heat penetration
  - run-off impacts