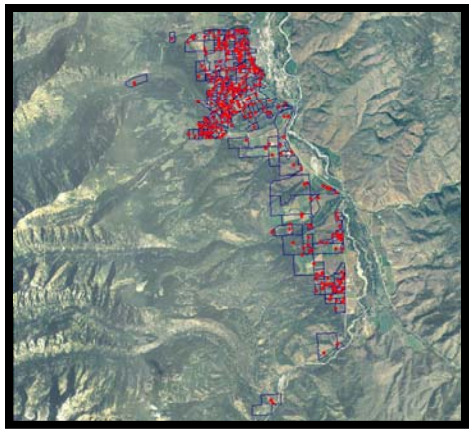
Results from a Cost Effectiveness Analysis of Preventive Mitigation Options for the Wildland Urban Interface



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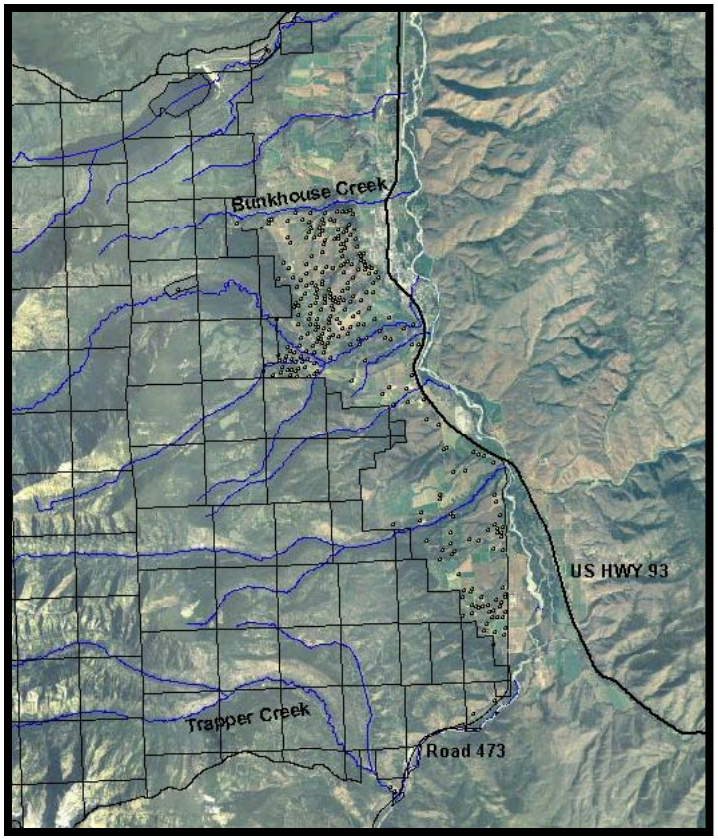
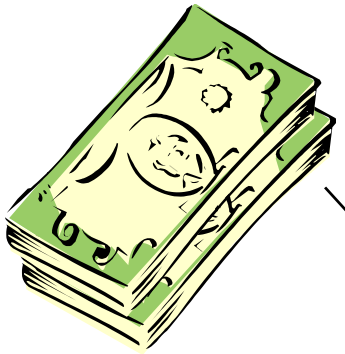
and
United States Forest Service,
Northern Region, Ecosystem Assessment and Planning /
Rocky Mountain Research Station, Economic Aspects of Forest Management on Public Lands

Problem Summary

- Rapid growth in the number of WUI homes at risk from wildfire
  - WUI growth rates in the US between 1990-2000 were estimated at three times that of non-WUI areas.
  - 8 million new WUI homes between 2000 and 2010 are projected.
- High suppression costs for land management agencies
  - WUI homes thought to be affecting suppression costs
  - Suppression budget growth as percent of budget
- A lack of cost-effectiveness information about preventative mitigation options for reducing the risk of structure loss.



What are cost-effective preventative mitigation options for reducing structure loss?



Firewise: Mitigation measures in the home ignition zones

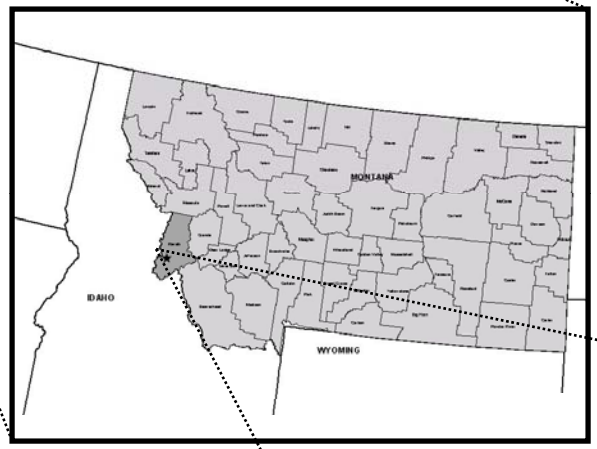
- *generally private homeowner responsibility*

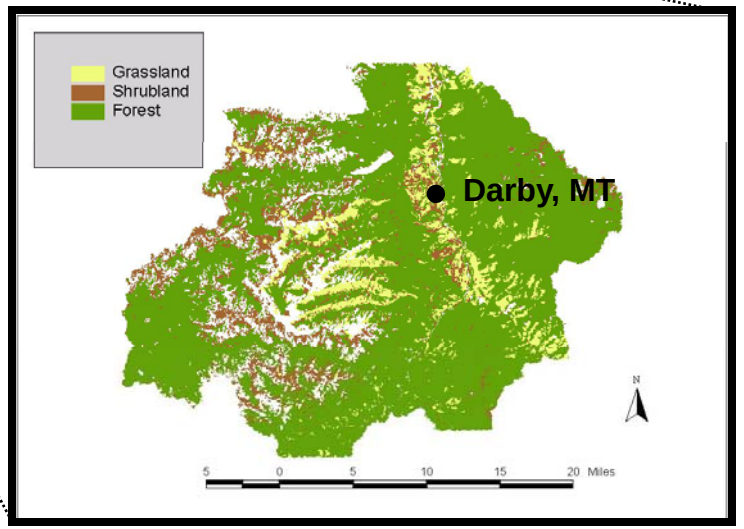
OR

Forest fuel reduction treatments in the interface/intermix

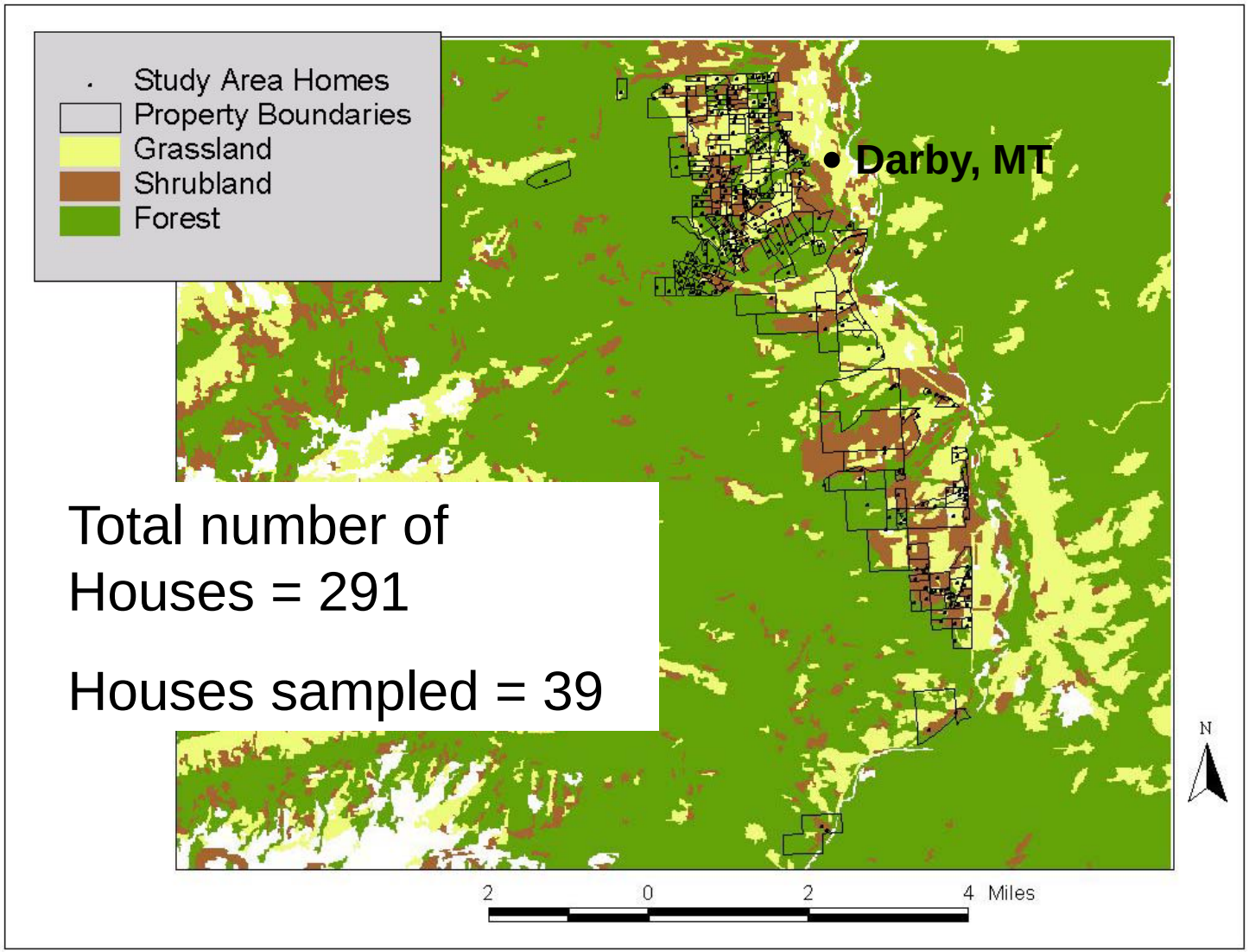
- *generally land management agencies' responsibility*

West Darby Study Area, Montana, USA





Home Locations in Study Area



Overview of Approach

1. **Current hazard**

   Hazard = Wildfire Prob (No Trx) * Home Ignition Prob (No Mitigation)

   - SIMPPLLE -- probability of wildfire reaching homes (No fuel treatment)
   - SIAM -- probability of home ignition if exposed to wildfire (w/o mitigation)

2. **Designing and testing Home Ignition Zone (HIZ) mitigations**

   Hazard = Wildfire Prob (No Trx) * Home Ignition Prob (with Mitigation)

   - SIMPPLLE -- probability of wildfire reaching homes (No fuel treatments)
   - SIAM -- probability of home ignition if exposed to wildfire (w mitigation activities)

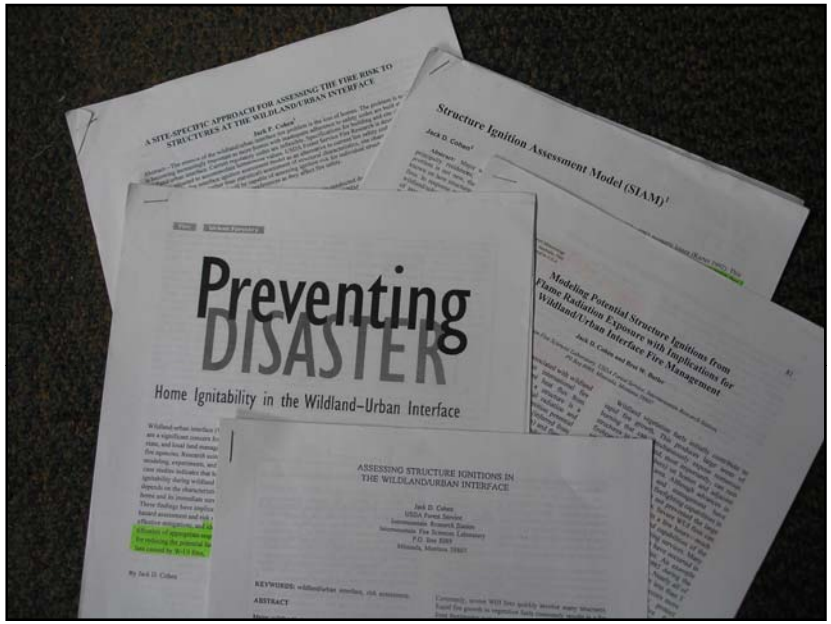
3. **Designing and testing fuel treatment schedules**

   Hazard = Wildfire Prob (With Trx) * Home Ignition Prob (No Mitigation)

   - SIMPPLLE simulating spatial fuel treatment schedules from MAGIS -- probability of wildfire reaching homes (with fuel treatments)
   - SIAM -- probability of home ignition if exposed to wildfire (w/o mitigation)

4. **Compare cost-effectiveness of results from steps 1-3**

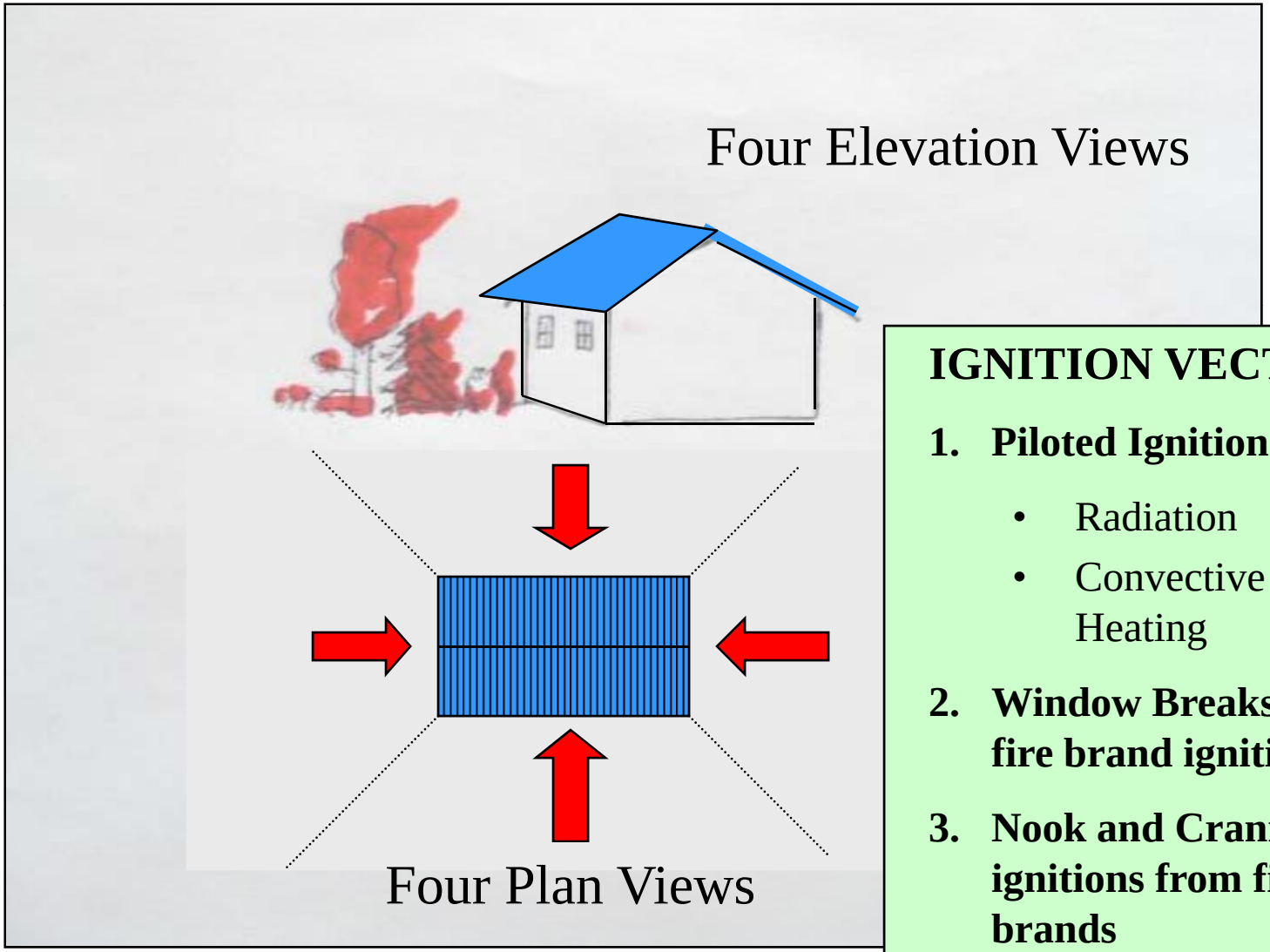
Structure Ignition Assessment Model (SIAM)



- Uses a combination of thermal calculations
  (based on experience from lab experiments, field testing, and post-fire investigations)
- Provides ignition expectations for structures exposed to wildland fire under extreme weather conditions

Designer: Jack Cohen, Missoula Fire Lab, RMRS

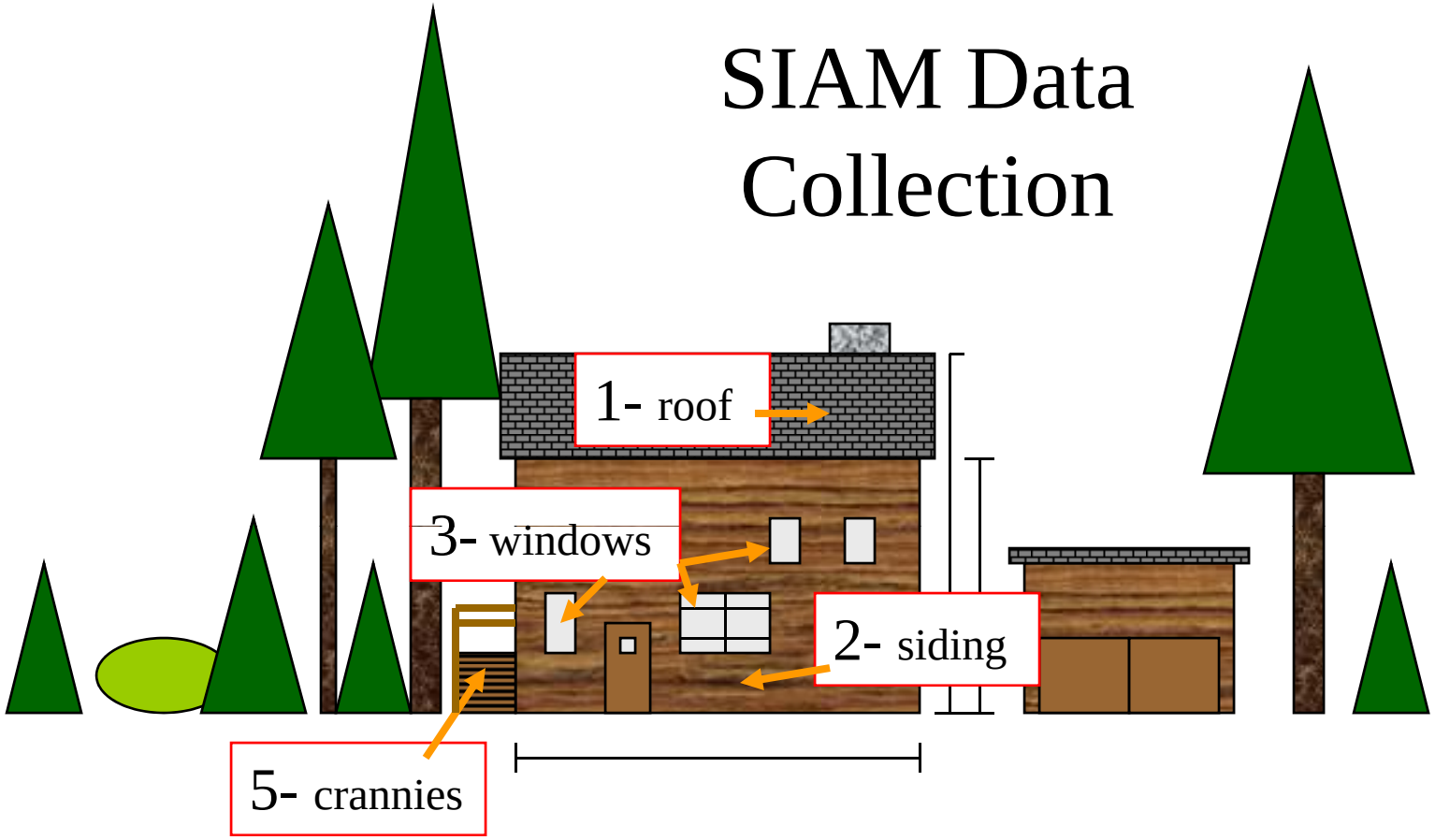
The SIAM Modeling Approach



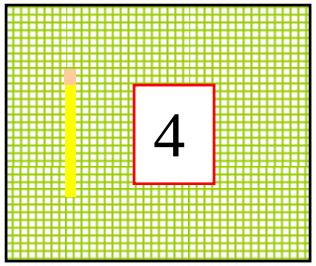
IGNITION VECTORS

1. **Piloted Ignition**
   - Radiation
   - Convective Heating
2. **Window Breaks with fire brand ignitions**
3. **Nook and Cranny ignitions from fire brands**

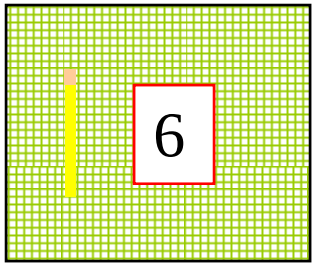
SIAM Data Collection



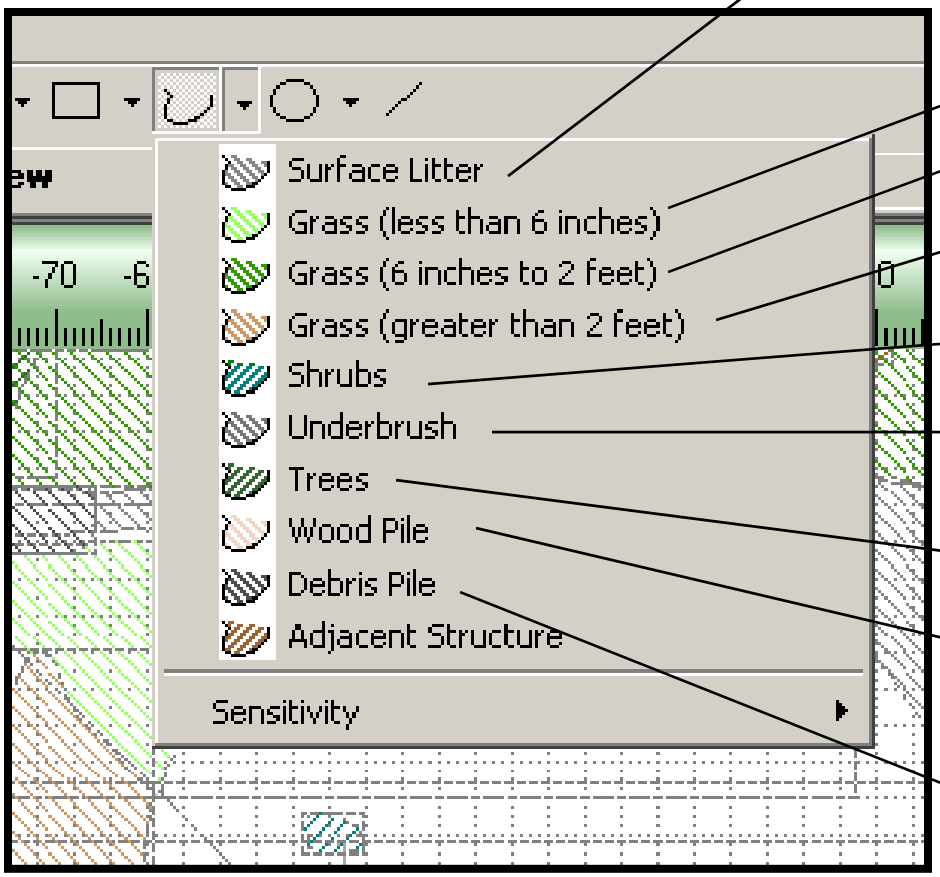
Draw Elevation Views

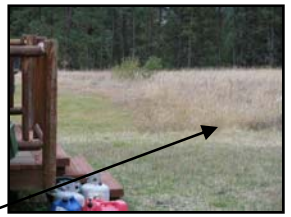


Draw Adjacent Fuel Views



Entering Adjacent Fuels





Drop-down digitizing tool

Ignition Probability for Sampled Houses (SIAM)

N = 39	Ignition Probability
Minimum	0.814
Maximum	1.000
Median	1.000
Average	0.994

Ambient Temperature = 90 Fahrenheit
Wind Speed = 20 MPH

SIMPPLLE

Simulating Patterns and Processes at Landscape Scales

United States Department of Agriculture – Forest Service
Rocky Mountain Research Station
RMRS

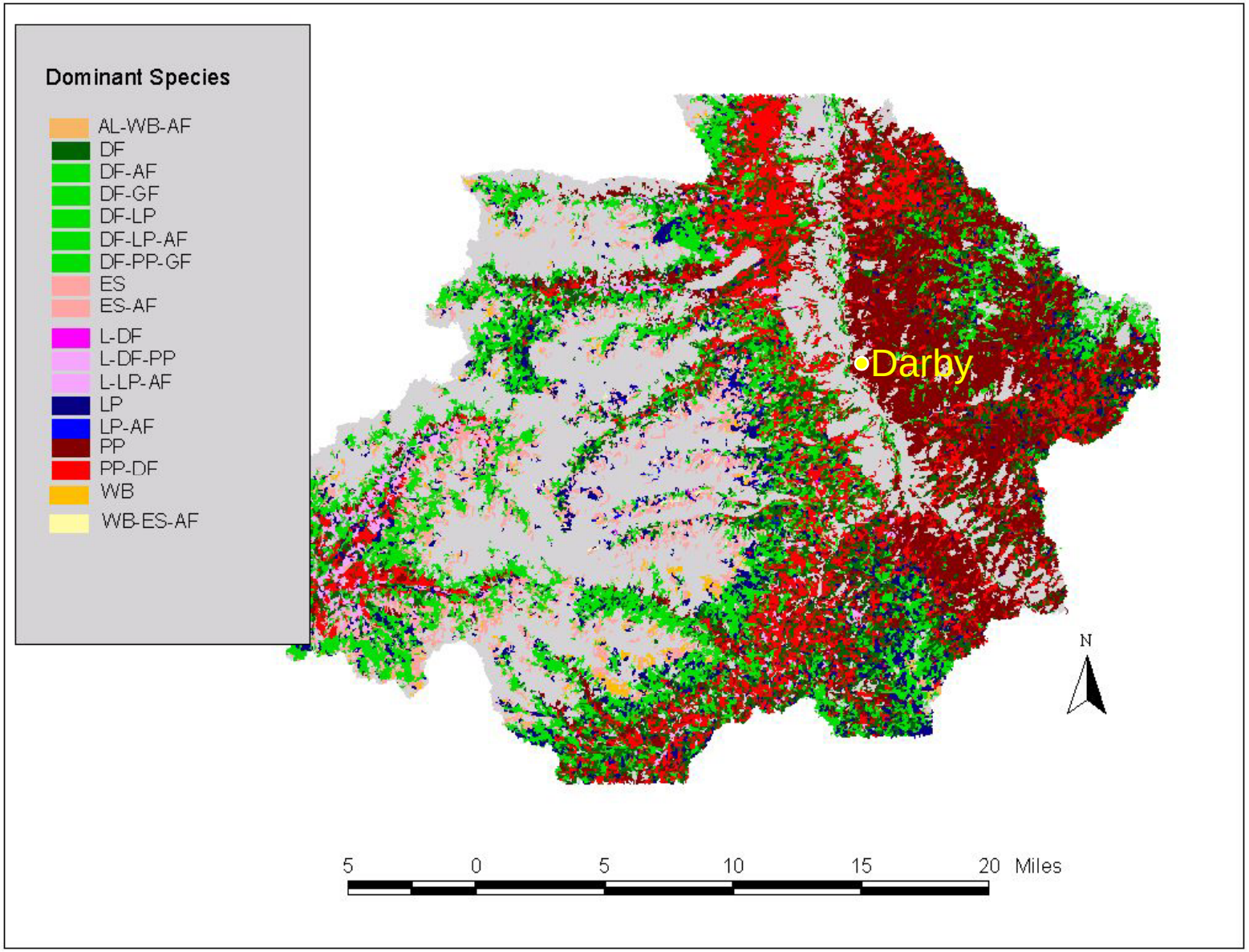
SIMPPLLE is a spatially explicit, landscape level, dynamic system for simulating vegetation disturbance processes:

- **Spatial and temporal**
- **Stochastic simulation of fire, insects, and diseases**
- **Expert opinion algorithms for spread of fire & other disturbance processes**
- **Ability to simulate management treatments**

West Darby Study Area:

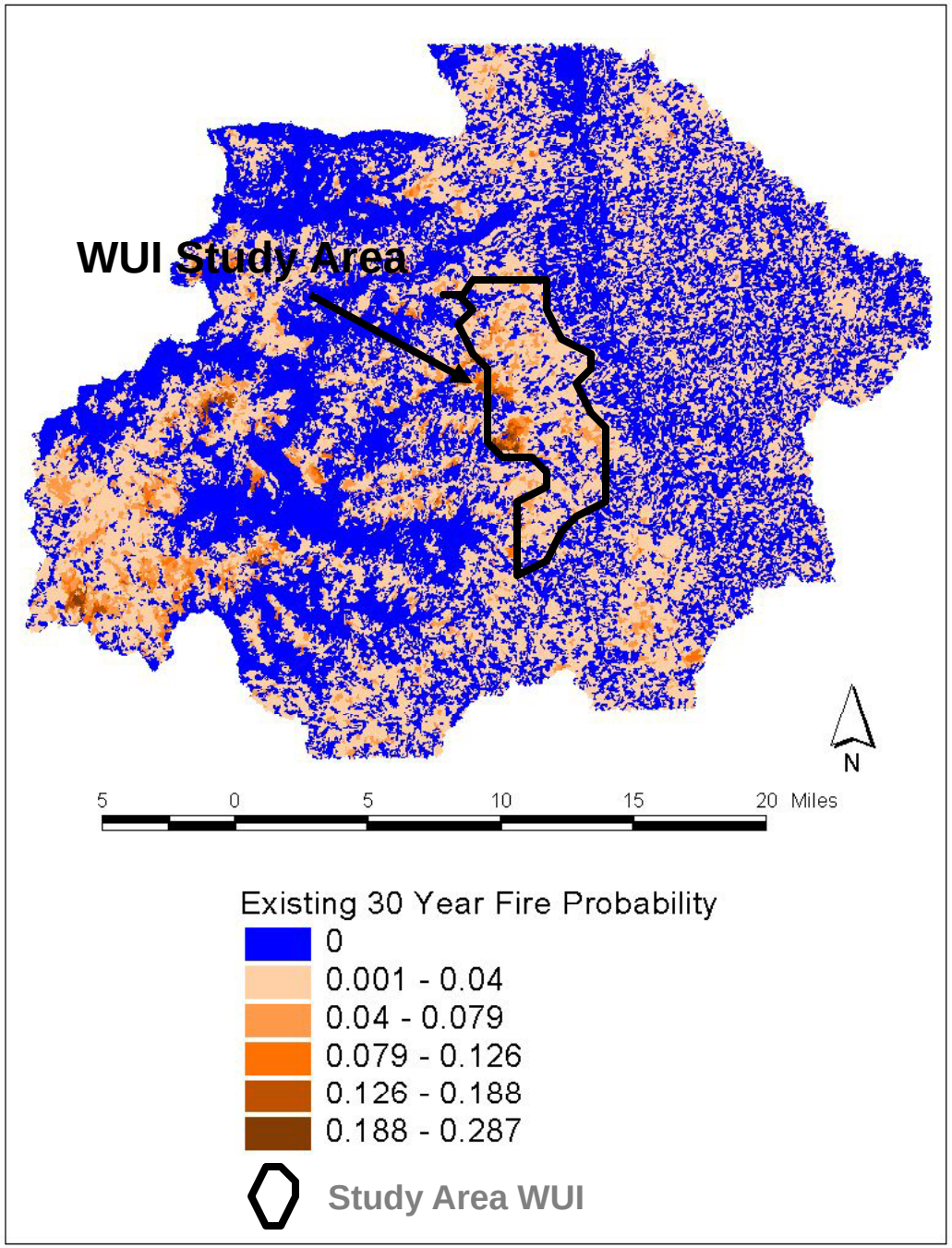
- **100 simulations** (per baseline and 7 treatment options).
- **Modeled with fire suppression**
- **Five percent extreme fire spread probability**
- **Local area specific fire data** (1995-2004 ignitions, and perimeter data)
- Historical (1995-2004) disturbance and forest management data is applied for model initiation

Forest Types -- West Darby Study Area



Wildfire Probability over 30 Years w/o Forest Fuels Treatment (SIMPPLLE)

Statistic	Wildfire prob. at home locations over 30 years
Min.	0 %
Max.	4.96%
Median	0 %
Average	0.486%
p = 0.0	211 Homes



Current Hazard Probability for Homes over 30 Years

Hazard = Wildfire Prob (No Trx) * Home Ignition Prob (No Mitigation)

Statistic	Current Hazard Probability
Minimum	0.0%
Maximum	4.96%
Average	0.484%
p = 0.0	211 residences

HIZ Mitigations Summary

A. Upgrade all single pane windows to double pane
B. Replace siding with non flammable material
C. Upgrade windows and replace siding
D. Light fuels conversion only
E. Light fuels conversion and replace siding
F. Full fuels conversion
G. Full fuels / Full building improvements

SIAM Modifications in the HIZ*

Option	Number of Homes with option available /39	Mean Ignition Probability for structures with option available, before and (after treatment)	Mean Ignition Probability for all 39 structures following treatment
A	7	1.000 (1.000)	0.994
B	33	0.962 (0.921)	0.927
C	7	1.000 (0.865)	0.927
D	36	0.993 (0.890)	0.898
E	30	1.000 (0.773)	0.799
F	39	0.994 (0.360)	0.361
G	39	0.994 (0.360)	0.361

MAGIS: Multi-resource Analysis and Geographic Information System

United States Department of Agriculture – Forest Service
Rocky Mountain Research Station
RMRS

MAGIS is a system for spatially scheduling forest vegetation treatments at the landscape scale:

- **Variety of vegetation treatments (Commercial and non-commercial thinning, Rx Burning)**
- **Multiple management objectives and constraints (Resource, econ, social)**
- **Computes treatment effects**
- **Road access component and slope used to assign yarding system**

West Darby Study Area:

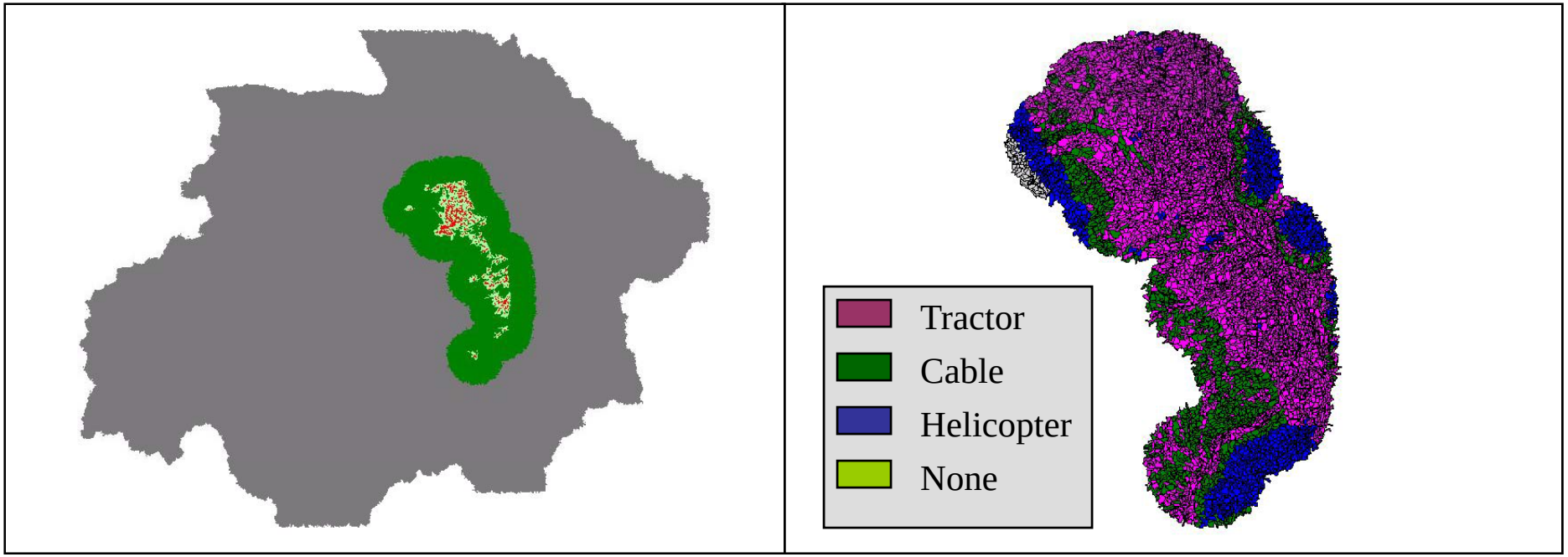
- **Optimized forest fuel treatment schedules for seven treatment budgets and five prescription options**
- **Objective: Select treatments to reduce average 30-year wildfire risk index (based on SIMPPLLE baseline (no treatment) simulations and expected treatment effectiveness**
- **Constraints:**
  - **Budgets**
  - **Total treatment area allowed per decade**
  - **Aggressive Prescriptions/Decade**
  - **Distance from houses <1.5 miles**

MAGIS Treatment Regimes

i. Prescribed fire only
ii. Prescribed fire following thinning cleanup
iii. Thinning small trees only
iv. Thinning small trees plus thin to 100ft^2/acre residual stand
v. Thinning small trees plus thin to 50ft^2/acre residual stand, plus two follow up prescribed burns

Thinning and Prescribed Burning Treatment Area

- The area we are working with now extends only 1.5 miles from the 291 structures



SIMPPLLE results with schedule mitigations

	SIMPPLLE Average	SIMPPLLE Median	SIMPPLLE Maximum	Host Polygons P= 0.00
Existing	0.00486	0.000	0.0496	200
Schedule A $184,080	0.00507 ↑	0.000	0.0592	189
Schedule B $2,135,048	0.00480 ↓	0.000	0.0493	199
Schedule C $2,319,128	0.00377 ↓	0.000	0.0492	211
Schedule D $1,235,075	0.00507 ↑	0.000	0.0397	196
Schedule E $3,370,123	0.00377 ↓	0.000	0.0492	209
Schedule F $3,284,920	0.00582 ↑	0.000	0.0496	178
Schedule G $5,604,048	0.00466 ↓	0.000	0.0494	197

Calculating Cost Effectiveness Ratios

Cost in $millions to achieve one percent effectiveness equals:

$$\frac{\text{Total Mitigation Cost}}{\text{Total Percent Effectiveness}}$$

For example:

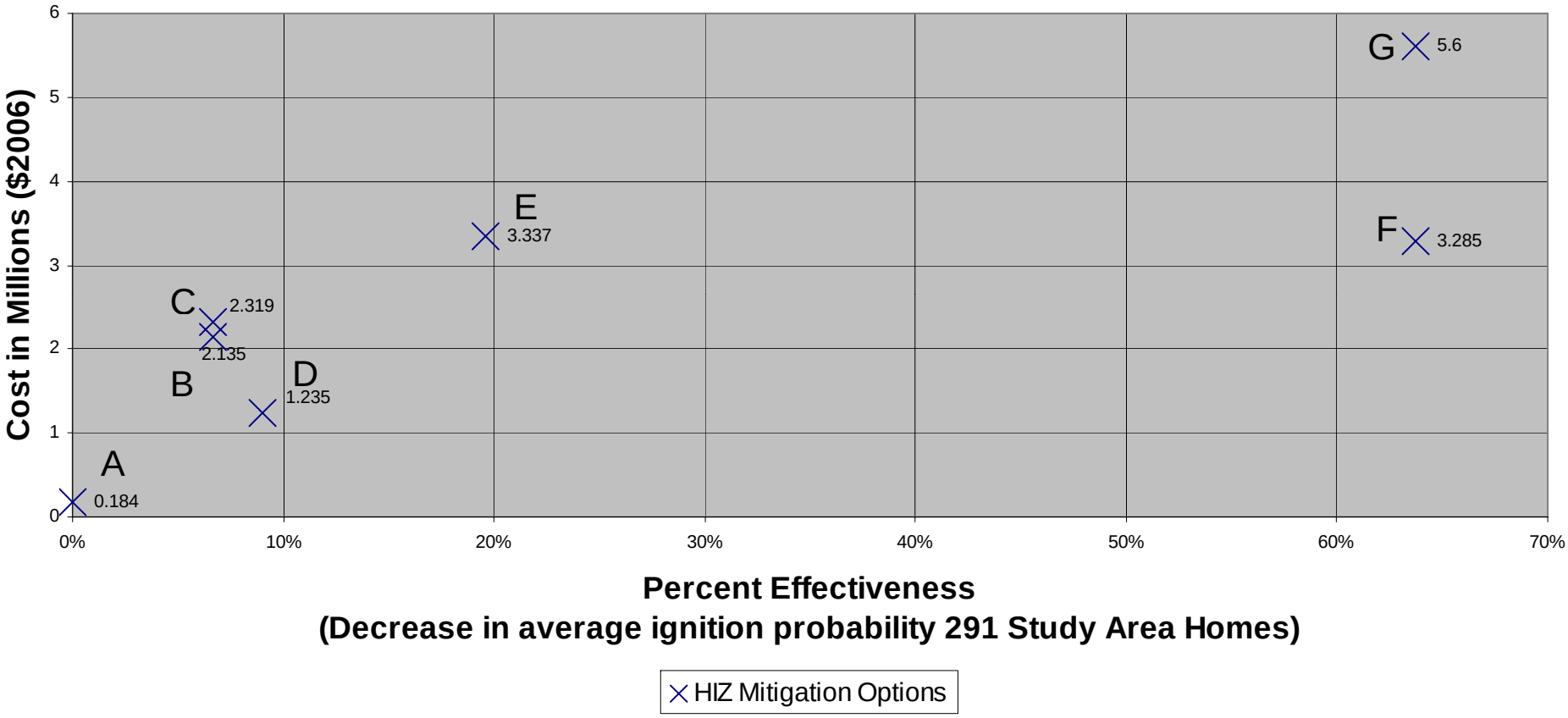
$$\frac{\$2{,}135{,}048}{6.7\%} = \$318{,}664 / 1.0\%$$

Ignition Probability Cost Effectiveness Results

SIAM	Number of Houses with option of 291	Cost per option ($million) 2006 Dollars	HIZ Mitigated hazard average for 291 homes (effectiveness)	HIZ CE Ratio[1] Cost / 1 percent Effectiveness / (RANK)
Existing Average	NA		0.994	
F. Full Fuels Conversion	291	3.284920	0.361 (-63.7%)	$51,569 (1)
G. Full Fuels Plus Siding and/or windows	242	5.604048	0.361 (-63.7%)	$87,976 (2)
D. Light Fuels	269	1.235075	0.898 (-9.0%)	$137,231 (3)
E. Light Fuels and Siding	242	3.370123	0.799 (-19.6%)	$171,945 (4)
B. Siding replacement	242	2.135048	0.927 (-6.7%)	$318,664 (5)
C. Windows and Siding	242	2.319128	0.927 (-6.7%)	$346,139 (6)
A. Window Upgrade	51	0.184080	0.993 (0.00%)	NA

[1] Although these ratios use $1MM as the denominator, this does not actually represent a possible scale of each mitigation option. This is used for comparison purposes only and should not be interpreted as indication that the application of each mitigation option is scaleable.

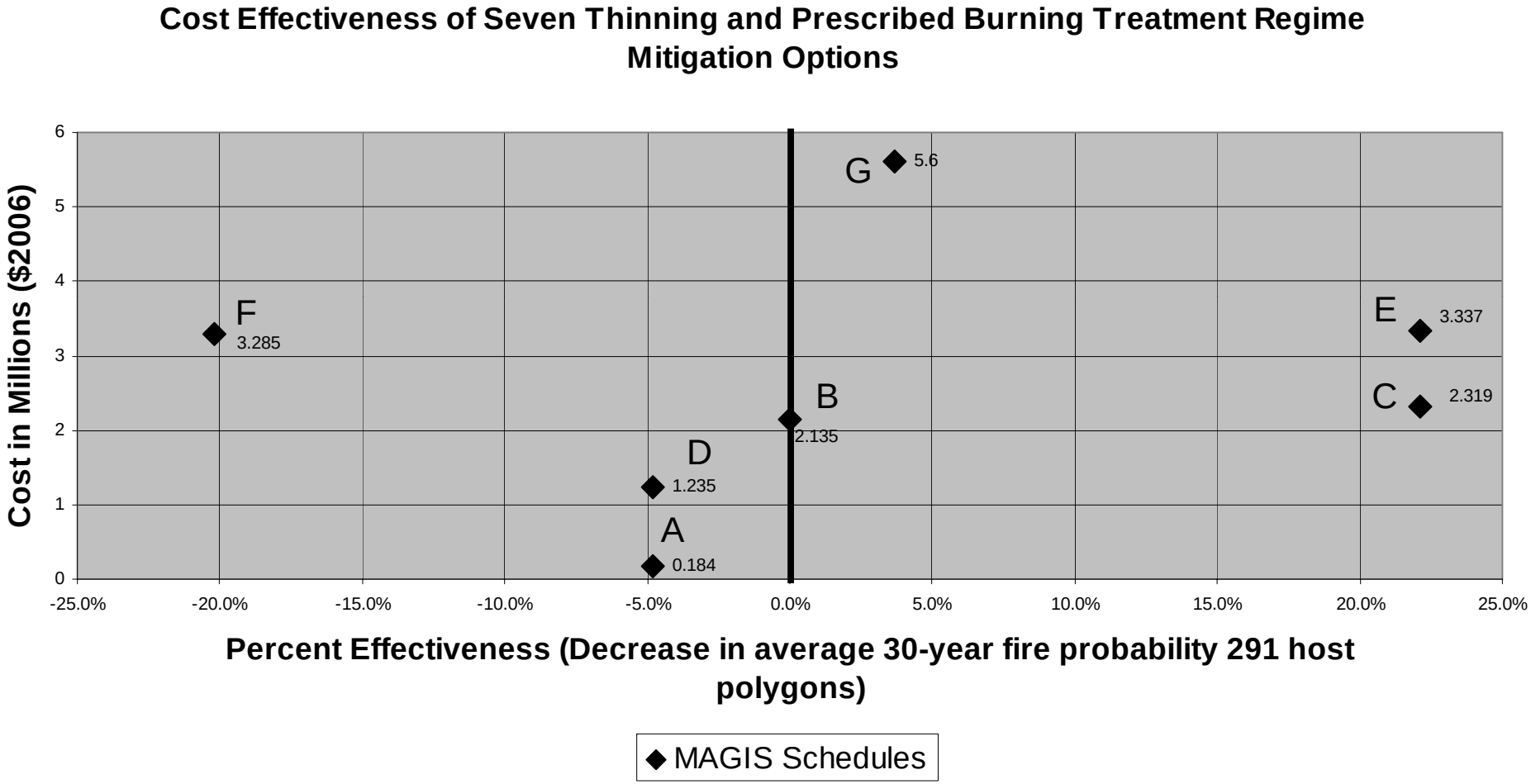
Cost Effectiveness of Seven Home Ignition Zone Mitigation Options



A.Windows
B. Siding
C. Windows and Siding
D. Light Fuels Conversion
E. Light Fuels and Siding
F. Full Fuels Conversion
G. Full Fuels/Full Building Upgrades

Thinning and Prescribed Burning Wildfire Probability Cost Effectiveness Results

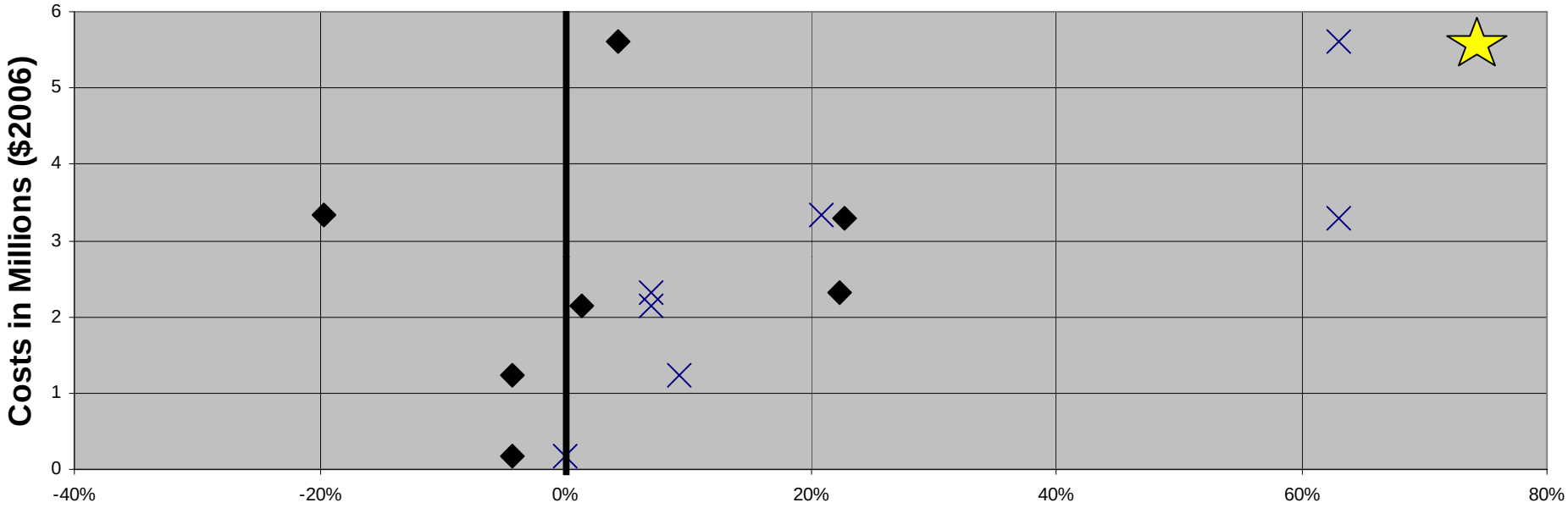
	Cost per option ($million) 2006 Dollars	MAGIS Mitigated average 30-year fire probability (effectiveness)	MAGIS CE Ratio Cost/ 1 percent Effectiveness (rank)
Existing Average		0.00486	
Schedule C	2.319128	0.00377 (-22.1%)	$104,938 (1)
Schedule E	3.370123	0.00377 (-22.1%)	$152,494 (2)
Schedule G	5.604048	0.00466 (-3.7%)	$1,514,608 (3)
Schedule B	2.135048	0.00480 (-0.01%)	$22,273,849 (4)
Schedule A	0.184080	0.00507 (+4.8%)	NA
Schedule D	1.235075	0.00507 (+4.8%)	NA
Schedule F	3.284920	0.00582 (+20.2%)	NA


Cost Effectiveness of Seven Thinning and Prescribed Burning Treatment Regime Mitigation Options
Cost in Millions ($2006)
6
5
4
3
2
1
0
G
5.6
F
3.285
E
3.337
B
2.135
C
2.319
D
1.235
A
0.184
-25.0%
-20.0%
-15.0%
-10.0%
-5.0%
0.0%
5.0%
10.0%
15.0%
20.0%
25.0%
Percent Effectiveness (Decrease in average 30-year fire probability 291 host polygons)
MAGIS Schedules

Modeling System (mitigation of existing hazard) CEA Results

	Cost per option ($million) 2006	**HIZ** Mitigated* hazard (effectiveness)	**HIZ** CE Ratio* Cost / 1 percent effectiveness	**MAGIS** Mitigated hazard (effectiveness)	**MAGIS** CE Cost / 1 percent effectiveness
Existing Average		0.00484		0.00484	
Window Upgrade / Schedule A	0.184080	0.00484 (-0.0%)	NA	0.00505 (+4.3%)	NA
Siding replacement / Schedule B	2.135048	0.00450 (-7.0%)	$305,007 (7)	0.00477 (-1.4%)	$1,525,034 (10)
Windows and Siding/ Schedule C	2.319128	0.00450 (-7.0%)	$331,304 (8)	0.00376 (-22.3%)	$103,997 (3)
Light Fuels / Schedule D	1.235075	0.00439 (-9.3%)	$132,804 (4)	0.00505 (+4.3%)	NA
Light Fuels and Siding / Schedule F	3.37123	0.00383 (-20.9%)	$161,250 (6)	0.00579 (+19.6%)	NA
Full Fuels Removal/Replacement / Schedule F	3.284920	0.00179 (-63.0%)	$52,142 (1)	0.00374 (-22.7%)	$144,710 (5)
Full Fuels Plus Siding and/or windows /Sch. G	5.604048	0.00179 (-63.0%)	$88,953 (2)	0.00463 (-4.3%)	$1,303,266 (9)

Cost Effectiveness Point Estimates
for 30-Year Hazards at all 291 Study Area WUI Homes



Summary Points

- Probability of a structure burning is high if exposed to wildland fire under severe burning conditions (SIAM)
- Probability of a wildland fire exposure to a specific structure is very low (SIMPPLLE)

  ➔The existing wildfire structure ignition hazard is low
- Mitigation in HIZ can be quite effective in reducing the probability of a structure burning if exposed to wildland fire severe burning conditions
- SIMPPLLE modeling of wildland fire on landscape:
  - Effects of forest fuel treatments on probability of wildland fire reaching structure locations is variable
  - Fire is not equally likely in all structure locations

What does this all mean?

- **Economics can be applied to mitigation decisions to improve the cost effectiveness of wildfire mitigation!**
- Approach provides potential for generating useful regional guides for communities based on home materials and vegetation/fuels
- Use in Community Wildfire Protection Planning
  - If hazard assessments include SIAM inputs for a representative sample, can predict hazard for all houses in area
  - Combine with landscape fire probabilities from agency modeling efforts

  ➔Community Wildfire Protection Plans could focus dollars and educational campaigns where they are site-specifically most cost-effective

What's Next?

- **Pending Joint Fire Science Program proposal for continuing this research:**
  - **Improving SIAM and making it available**
  - **Substituting wildfire behavior models to expand the questions that can be addressed**
  - **Working with community wildfire planners to fine tune approach to meet their needs**
  - **Beta testing an improved system on three communities**
  - **Deliverable: User-friendly system that can be used by communities to support their CWPP strategies**
- **Adding additional protection priorities to the analysis**
  - **Other infrastructure**
  - **Resource values**

Additional Protection Priorities

- Critical infrastructure,
- Timber values
- Land value
- Aesthetics
- Sensitive wildlife habitat,
- Soil productivity,
- Air quality

Ecosystem functions

(Graham et al. (2004) Weaver 1943, Reynolds et al. 1992, Covington and Moore 1994, Covington et al. 1997, Fulé et al. 1997, Swetnam et al. 1999, Conrad et al. 2001, Kalabokidis et al. 2002, Cohen and Stratton 2003).

Project Partners

The University of Montana

College of Forestry and Conservation,
Department of Forest Management

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United States Department of Agriculture – Forest Service
Rocky Mountain Research Station

NORTHERN REGION USFS
Striving for Excellence
CARING FOR THE LAND • SERVING PEOPLE

USDA, Forest Service, Northern Region

Questions?

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