THE RELEVANCE OF REGIONAL-SCALE HABITAT MODELS TO FISHER CONSERVATION

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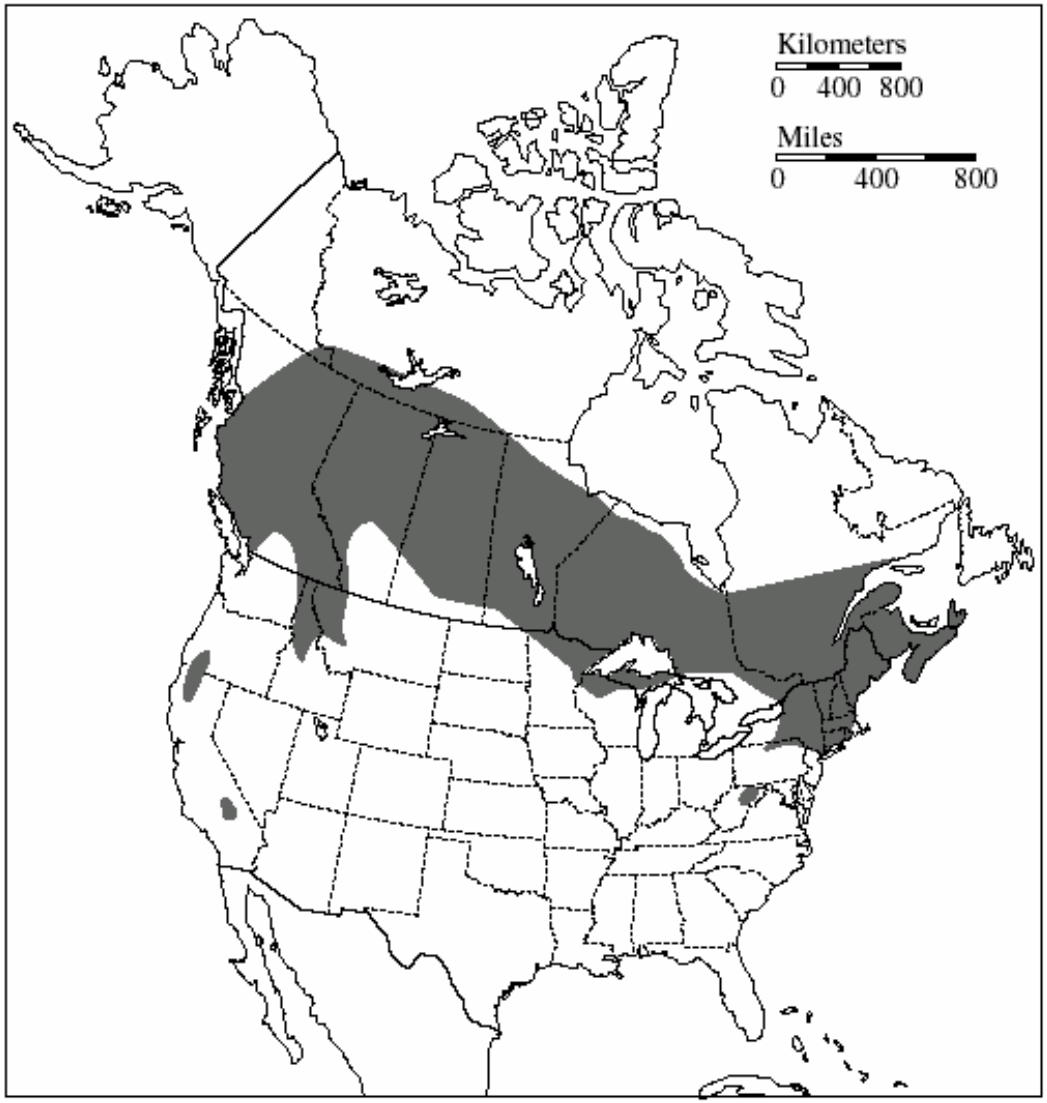
Photo credit: M. Higley

Reasons for conservation concern

- Lack of knowledge of habitat associations and distribution
- Evidence for range contraction in some areas
- Low population density, dispersal limitations, and large area requirements suggest need for regional-scale conservation strategies
- More controversially, has been hypothesized to be associated with older forest in some areas



RANGE OF THE FISHER

Marginal distribution in the western US suggests concerns regarding minimum area and connectivity required for population viability

Potential predictor variables for regional-scale distribution models

- Remotely-sensed vegetation data (forest cover)
- Prey distribution and abundance (ungulate biomass index)
- Physiographic (snowpack, topographic relief)
- Human impact factors (roads, population)

Previous fisher habitat models: Carroll et al. 1999

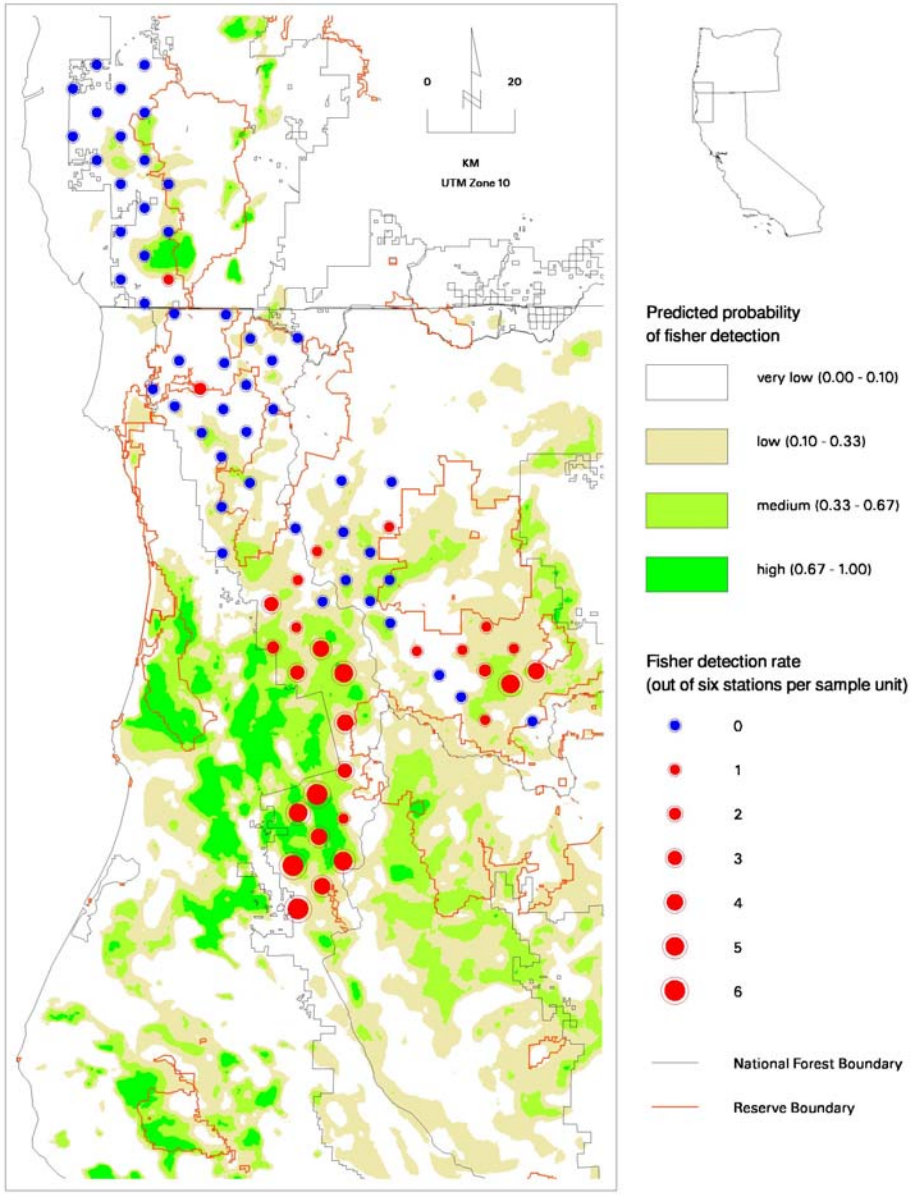
Purpose:

Develop and test regional-scale habitat model for Klamath/North Coast Interior region

Data:

Model development:
Opportunistic and systematic (non FIA-based) surveys from Klamath region (n = 682)

Model validation: FIA-based systematic surveys from Klamath region (n=468)



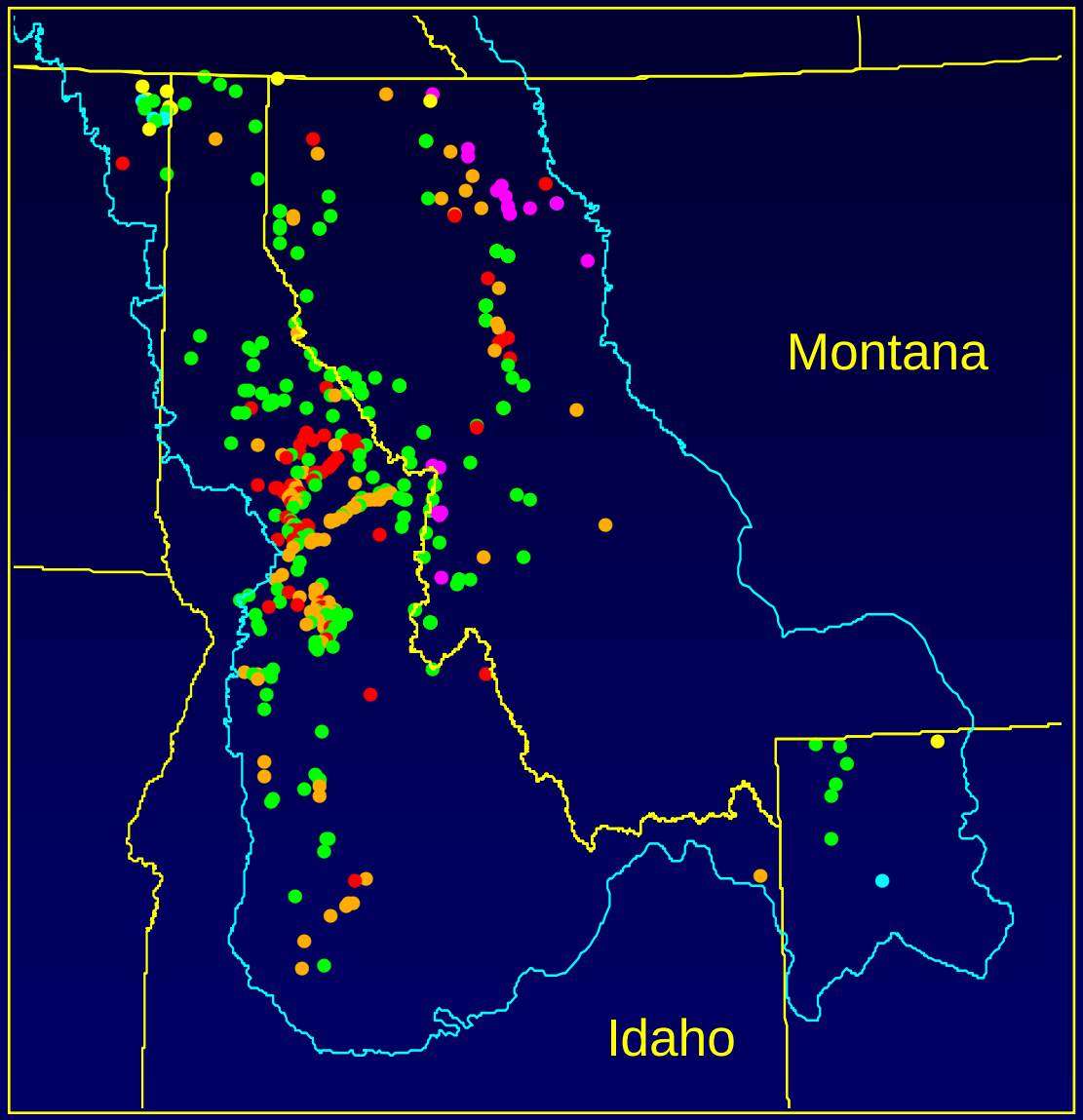
Model results:
Carroll et al. 1999
Conservation Biology

Variables:
Tree canopy closure
Tree size
Percent conifer
Annual rainfall
UTM Northing

Results: Carroll et al. 1999

The correct classification rate of 78.6% with the new data was similar to that achieved with the original data set (80.4%).

Whereas several fine-scale habitat attributes were significantly correlated with fisher presence, the multivariate model containing only landscape and regional-scale variables performed as well as one incorporating fine-scale data, suggesting that habitat selection by fishers may be dominated by factors operating at the home-range scale and above.



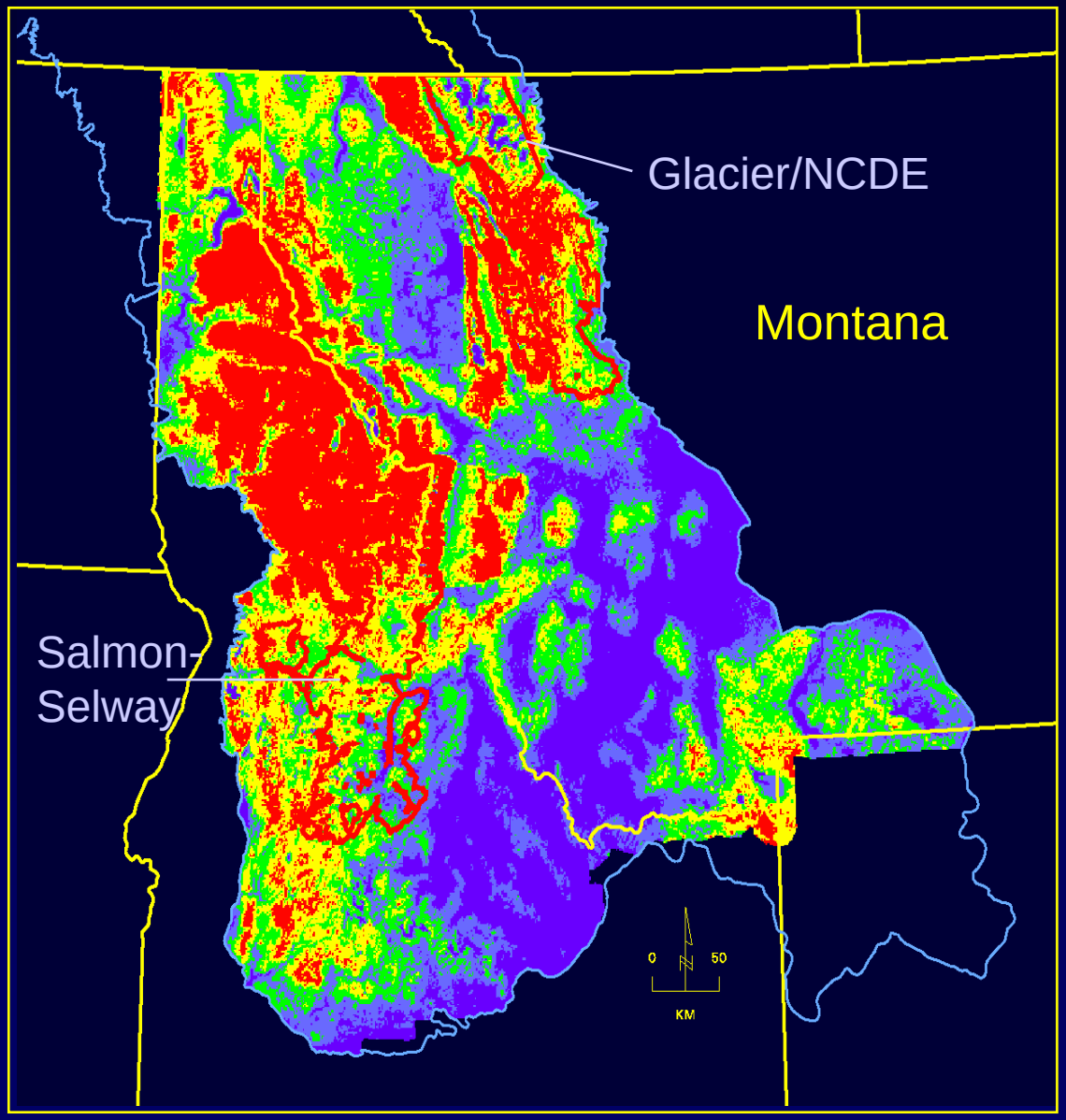
Carroll et al. 2001
Ecological Applications
Fisher Occurrence Data
US Northern Rockies

(n = 456)

RELIABILITY LEVEL

- 1 Specimen or Photo
- 2 Trapping Report
- 3 Sighting by Expert
- 4 Sighting
- 5 Tracks Reported by Expert
- 6 Tracks

Study Area Boundary



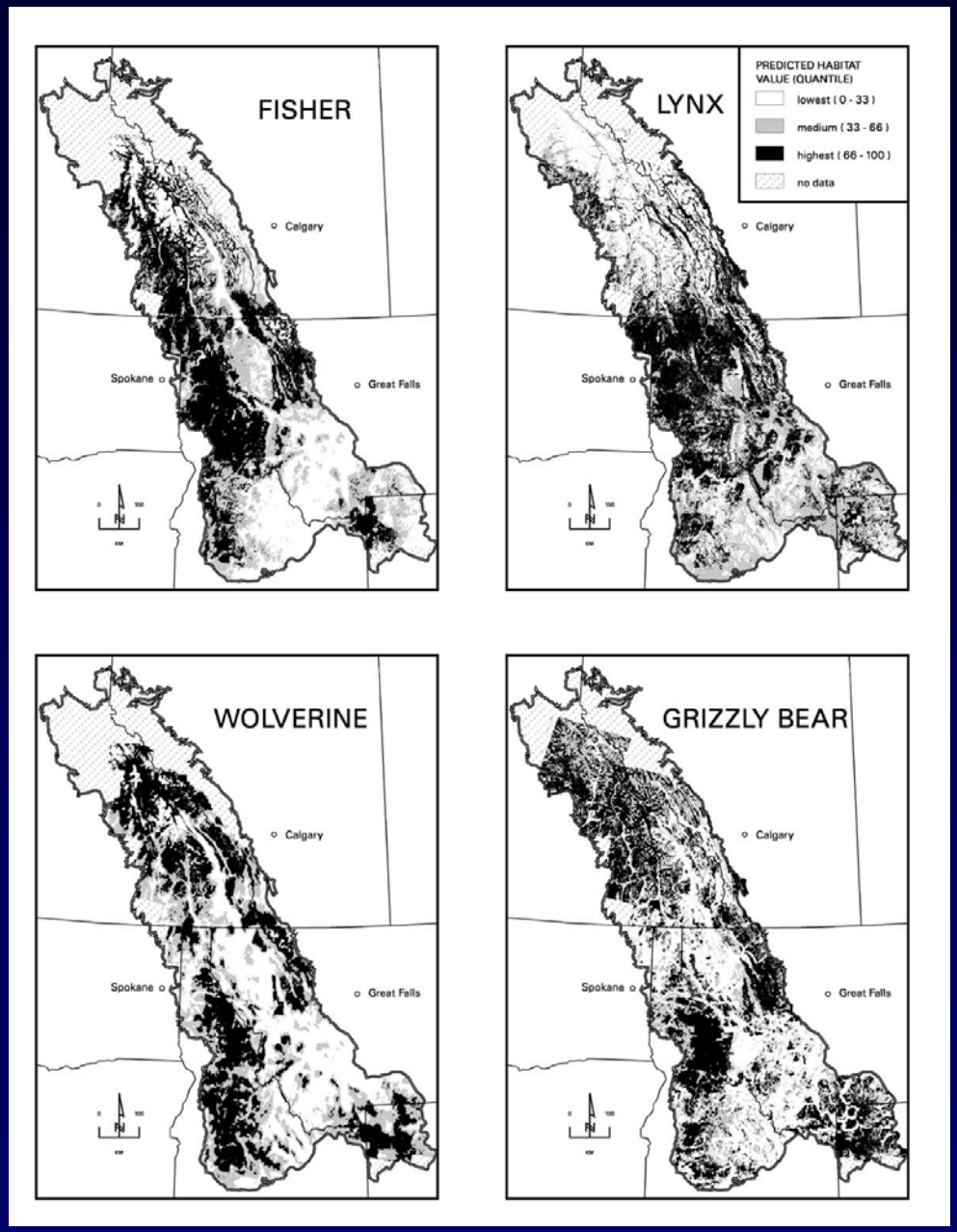
Carroll et al. 2001
Predicted Distribution
of the Fisher

US Northern Rockies

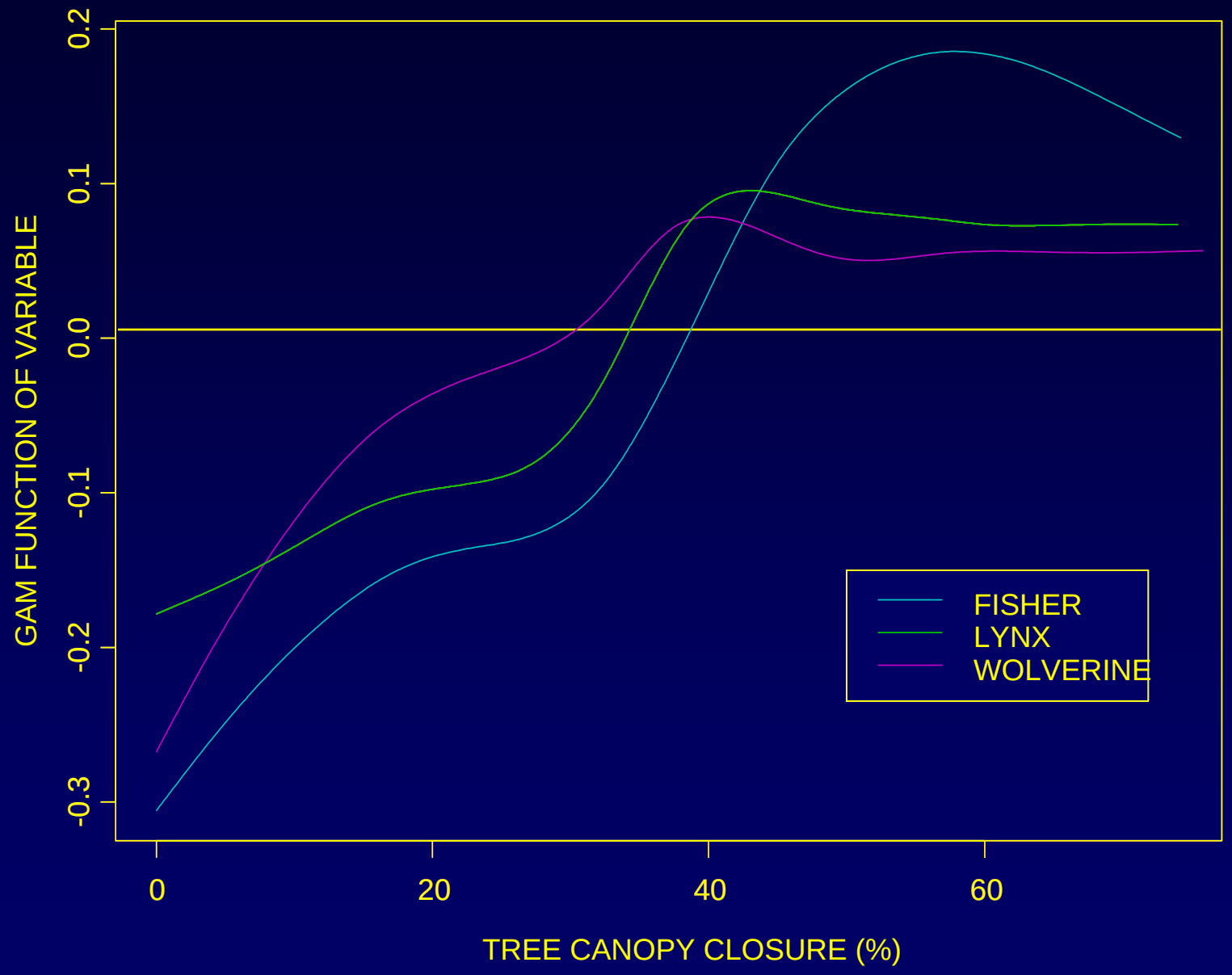
Model Variables:

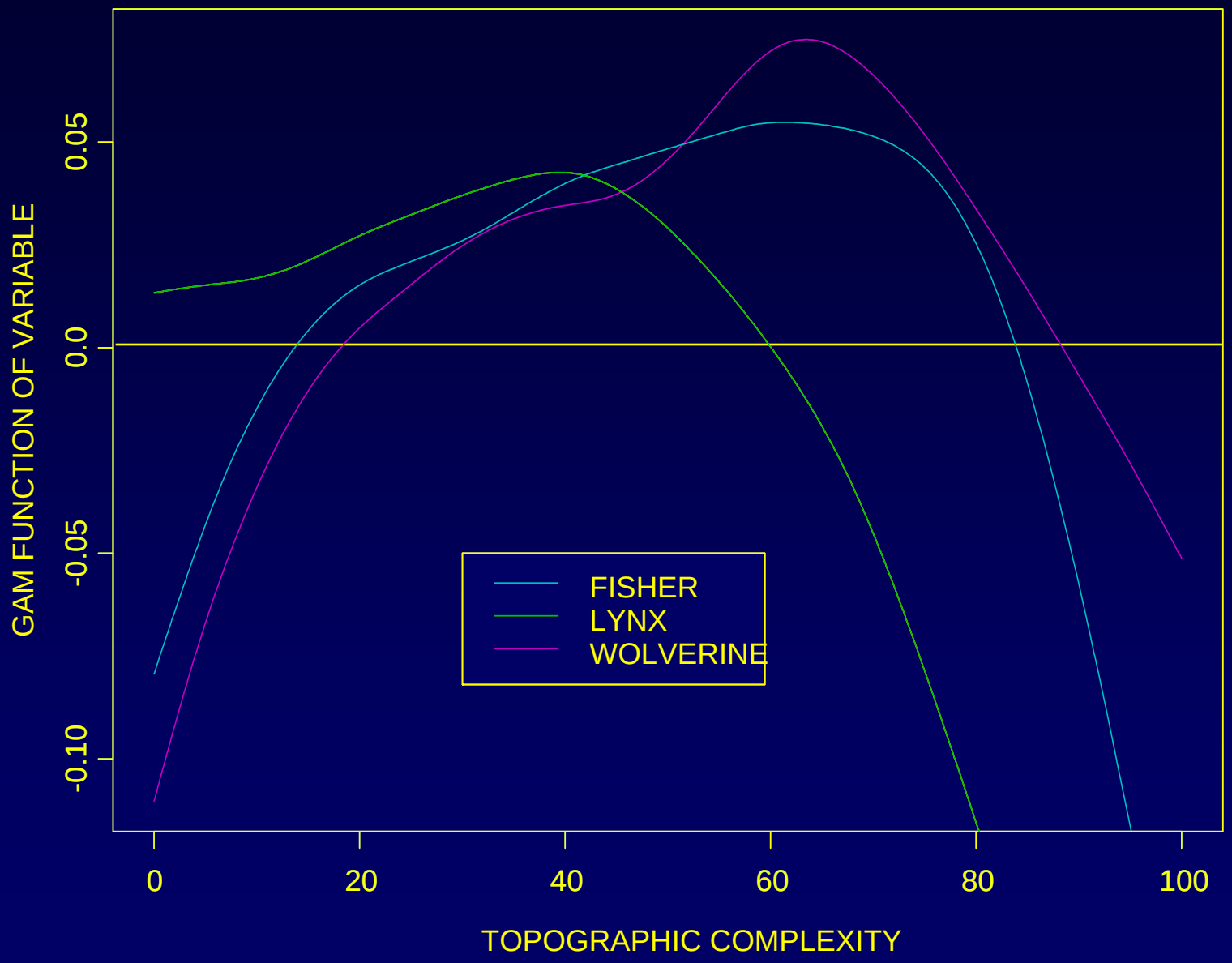
Tree Canopy Closure (+)
Tasseled-Cap Greenness (+)
Tasseled-Cap Wetness (-)
Precipitation (quadratic)
Elevation (-)

— Study Area Boundary



Contrasts in habitat associations between focal species


GAM FUNCTION OF VARIABLE
0.2
0.1
0.0
-0.1
-0.2
-0.3
0
20
40
60
TREE CANOPY CLOSURE (%)
FISHER
LYNX
WOLVERINE


GAM FUNCTION OF VARIABLE
0.05
0.0
-0.05
-0.10
0
20
40
60
80
100
TOPOGRAPHIC COMPLEXITY
FISHER
LYNX
WOLVERINE

Model re-analysis for redwood zone: Carroll 2005 (available at klamathconservation.org)

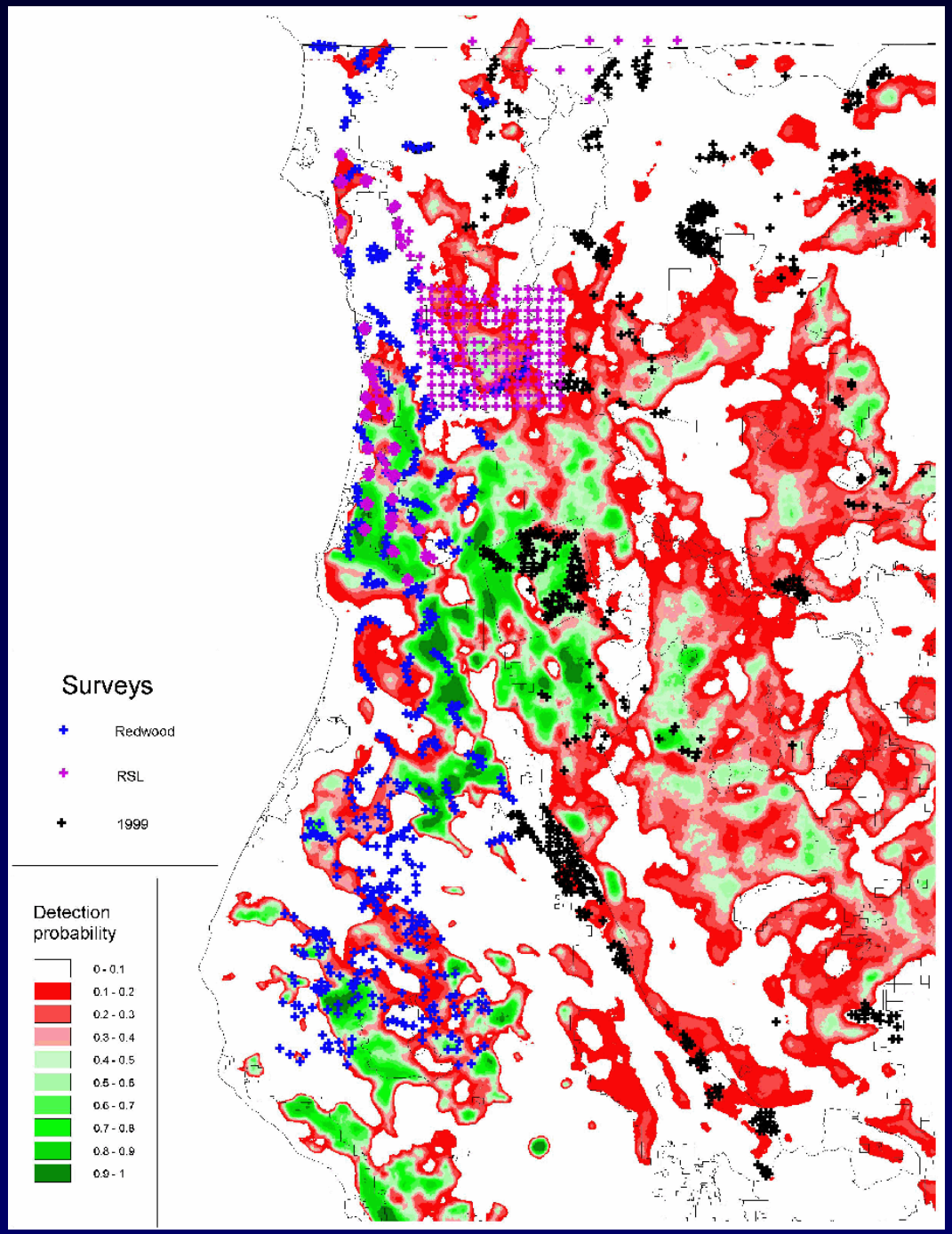
Question: Are the 1999 model results general enough to support

1) Identifying areas of high suitability in the redwood zone that might serve as sources of animals for reintroduction elsewhere
2) Identify potential limiting habitat factors and high suitability areas in the Sierra Nevada

Purpose:

1) Test ability of 1999 model to predict detection rate in redwood zone
2) Compare univariate models between Klamath and redwood zone
3) Develop new models from both Klamath and redwood data for northwestern California and Sierra Nevada

Data: 1160 locations surveyed between 1994 and 2004 by Green Diamond, PALCO, Humboldt State Univ., and USFS Coastal Marten Project.



Results: Significance tests - The 1999 model was a significant ($p < 0.05$) predictor of survey success in the redwood zone for the overall data set and for 5 of the 9 component data sets (two-sample t-test, Table 1). All trends were positive in that sites with detections had higher predicted probability even in those data sets where the difference was not significant.

Table 1. Results of t-tests comparing redwood zone fisher survey data sets with predictions from Carroll et al. (1999) model. GDR = Green Diamond, HSU = Humboldt State University, PALCO = Pacific Lumber, RSL = Redwood Sciences Laboratory. A positive trend indicates that fisher detection sites showed higher predicted probability than non-detection sites.

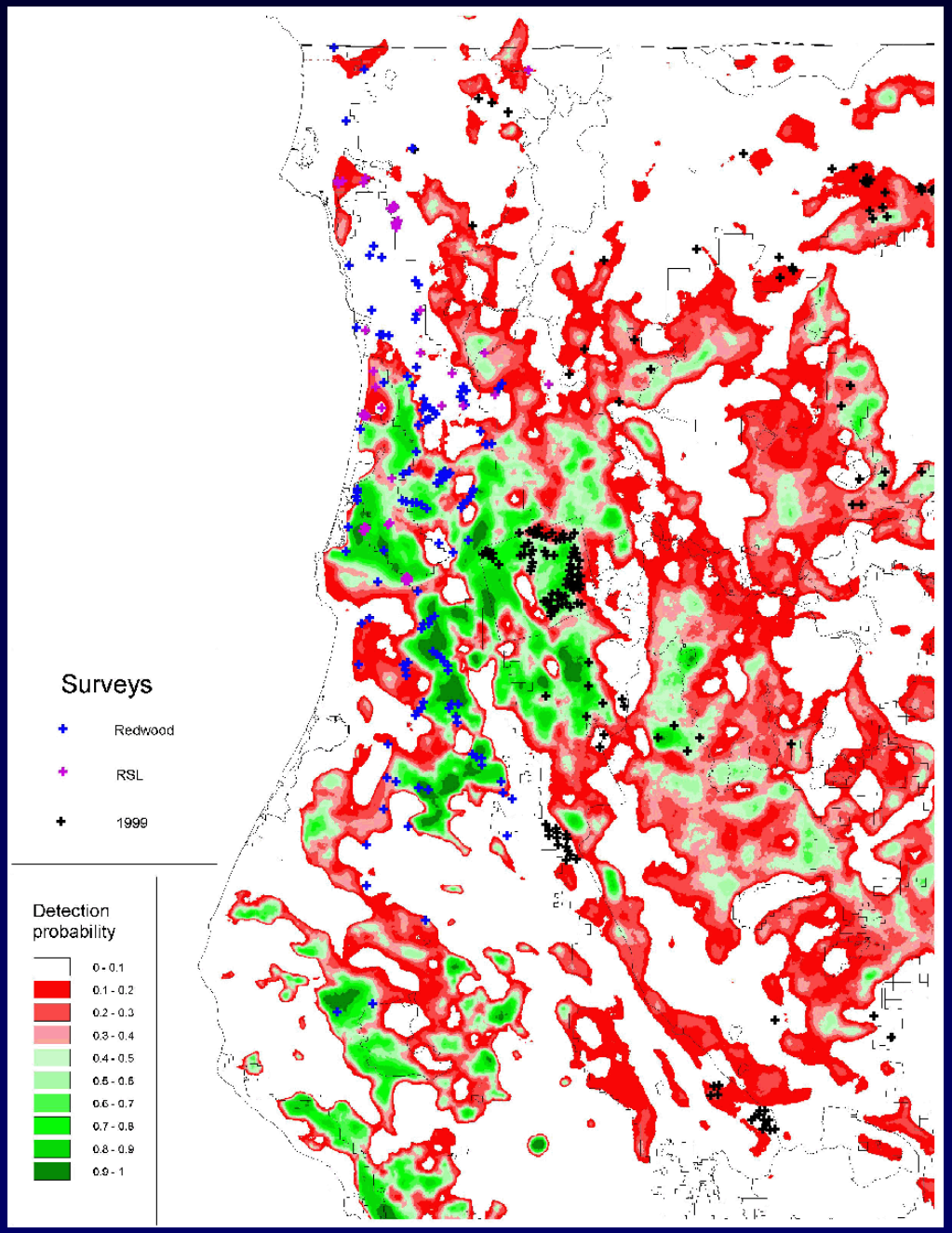
DATASET	SIZE	% DETECTION	P-VALUE	TREND
GDR1994	238	18.1	0.0445	+
GDR1994R	48	22.9	0.0011	+
GDR1995	236	21.2	0.0188	+
GDR1995R	66	21.2	0.2743	+
GDR2004	230	14.8	0.0038	+
GDR2004R	48	10.4	0.937	+
HSU	119	9.2	0.4352	+
PALCO	175	5.7	0.0137	+
RSL	364	12.9	0.3026	+
OVERALL	1524	14.8	<0.001	+

DISCUSSION: SIGNIFICANCE TESTS

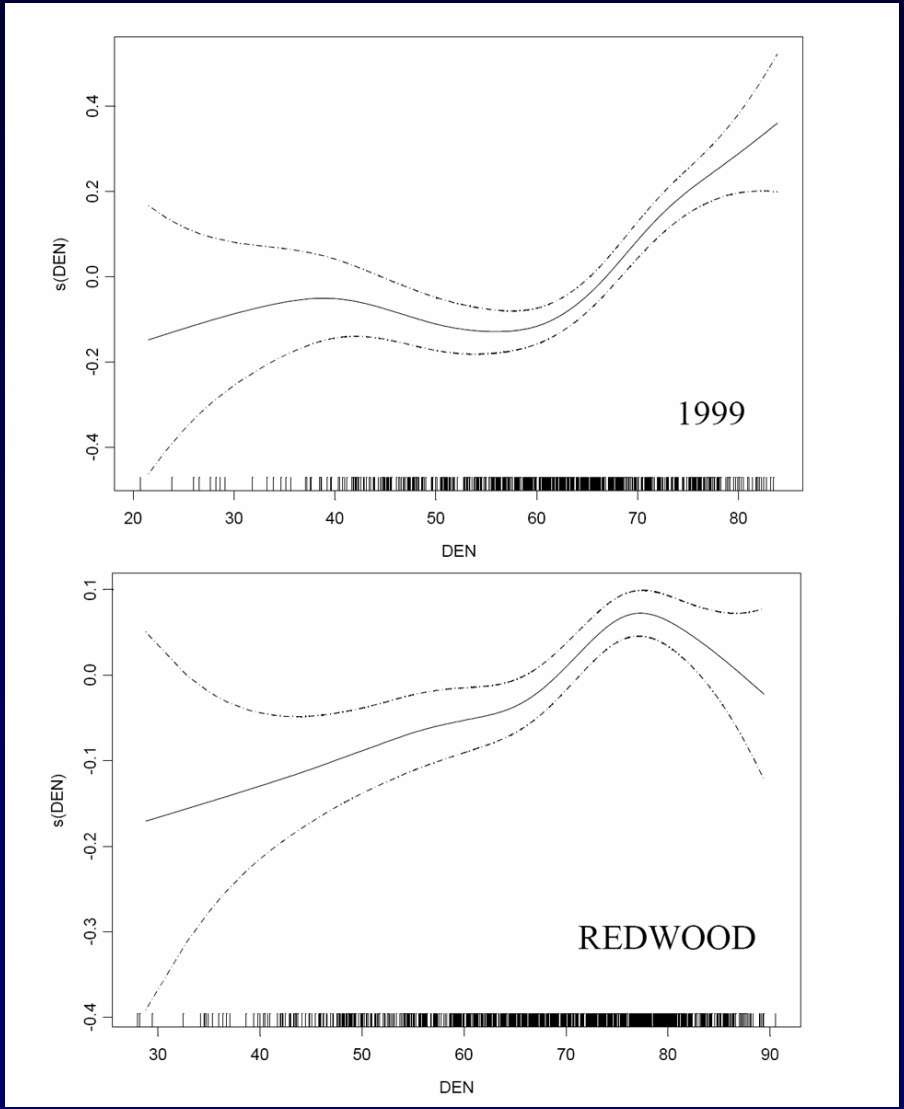
Fit encouraging, suggest generality of environmental factors such as canopy closure between ecoregions. But patterns in lack of fit may be due to:

1) Sample size – Smaller data sets had poorer fit
2) Change in vegetation over time – Between date of vegetation data (1990) and surveys (1994-2004).
3) Seasonal effect – Summer/fall surveys had poorer fit than winter/spring surveys (due to poorer survey efficacy or seasonal changes in selection?)
4) Geographic patterns in model performance: Due to inability of 1999 modeling techniques to fully capture spatial structure in fisher distribution

Pattern of detections: Redwood and Klamath data, as compared to 1999 predictions



RESULTS:
Univariate relationships of detection with predictor variables



Results: Model re-analysis for redwood zone
Comparison of multivariate model coefficients

Table 2. Coefficients in logistic regression models fit with interior, redwood, and combined fisher survey data sets. NS = not significant.

VARIABLE	1999	REDWOOD	COMBINED (Model 1)
Density	0.5365416	0.07573566	0.1971670
Size Class	-0.1287142	2.651877	0.00940196
%Conifer	0.4492566	0.01100843(NS)	0.1584445(NS)
Precipitation	-0.01409821	0.003927531(NS)	-0.0005342987
UTMN	0.001347394	0.005498617(NS)	0.002434118
$UTMN^2$	$-1.495646*10^{-10}$	$-6.050976*10^{-10}$	$-2.667851*10^{-10}$
Density*%Conifer	-0.005364044	-0.0007361238(NS)	-0.002409484
Size*Precipitation	0.005575764	-0.001101238(NS)	-0.00009.847074(NS)

Results: New models developed from combined redwood and Klamath data

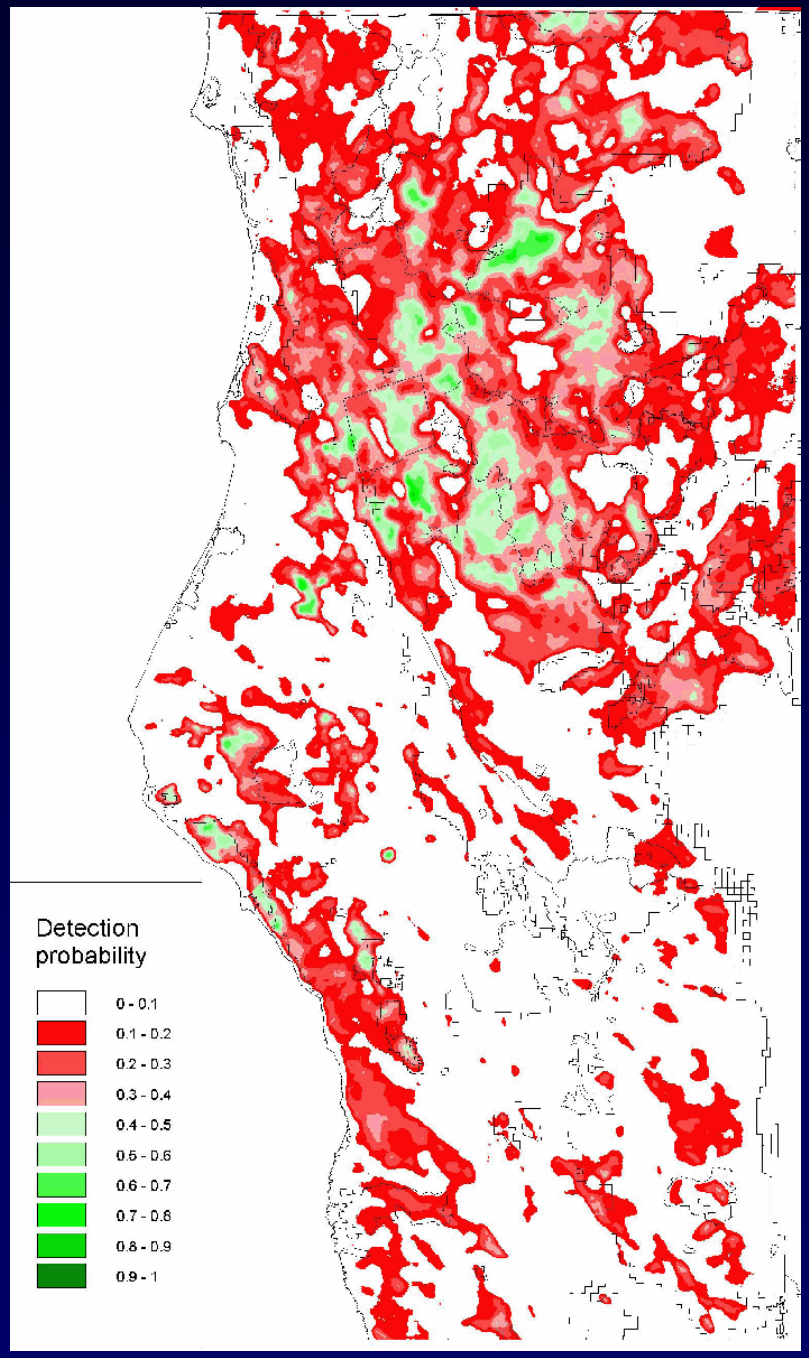
Model 2 – Similar variables to 1999 model, but without trend surface variables

Model 3 – “Minimal” model containing 2 variables with highest univariate significance (Density and Terrain Ruggedness)

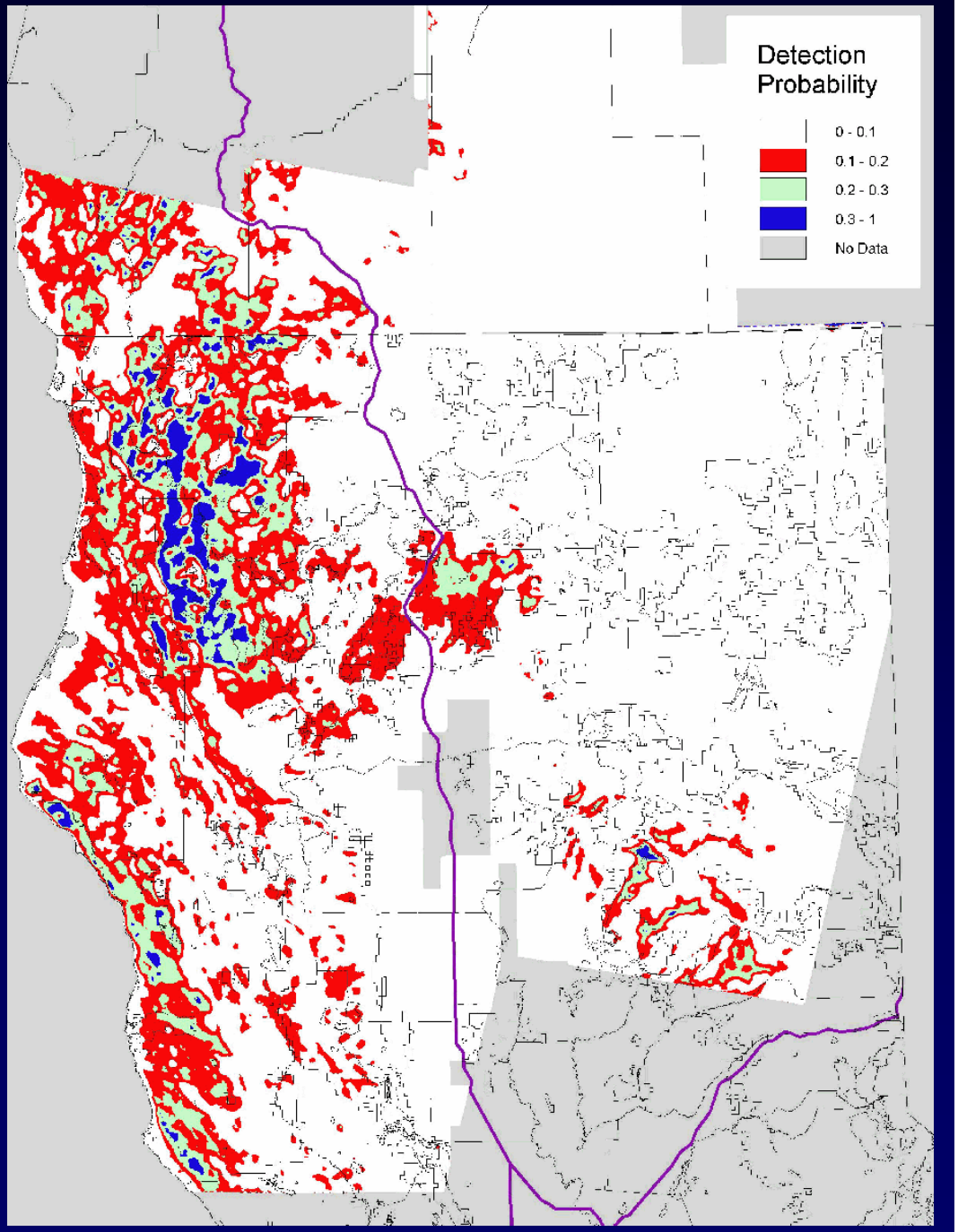
Table 3. Coefficients in new logistic regression models fit with combined fisher survey data sets.

VARIABLE	Model 2	Model 3
Density	0.262561	0.04594283
Size Class	-2.127242	
%Conifer	0.2080611	
Precipitation	-0.0009734838	
Density*%Conifer	-0.002673655	
TRI	0.02816412	0.0226603

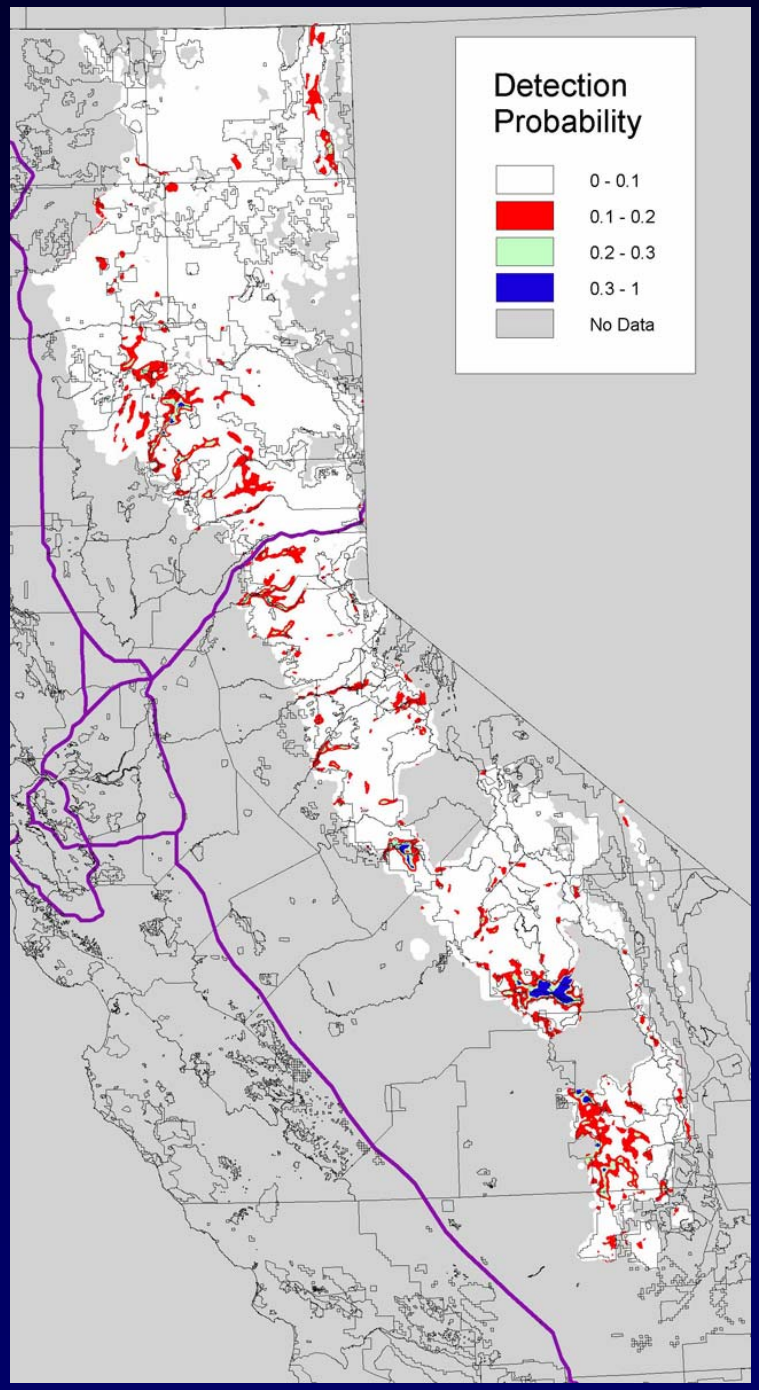
New models developed from combined redwood and Klamath data – Model 2 (1999 + TRI)



New models developed from combined redwood and Klamath data – Model 3 (DEN + TRI) using KBAP vegetation data



New models developed from combined redwood and Klamath data – Model 3 (DEN + TRI) using USFS vegetation data



DISCUSSION: MODEL COMPARISONS

Carroll et al. 1999 modeled spatial structure with a moving-average function and regional trend surface variables. These techniques have limitations in their ability to mimic the underlying biological processes causing spatial dependence in the data. The trend surface variables especially are likely to have poor generality if the model is extrapolated outside the spatial extent of the original data set.

New tools involving MCMC techniques (e.g., WINBUGS) may allow distribution models that incorporate both local factors and metapopulation effects. Such spatial models also resolve problems of pseudo-replication caused by incorporating repeated surveys at neighboring sites. Spatially-explicit population models such as PATCH (Schumaker 1998) could provide a complementary tool.

What is recovery?

The Endangered Species Act (ESA) says little about what defines a recovered population. One might suppose that it is the opposite of the ESA's definition of threatened status, i.e. NOT threatened across "a significant portion of its range". (Vucetich et al. in press)

Other potential benchmarks include:

- Historic population size: e. g., as assessed by genetic analyses (e.g., for wolves, Leonard et al. 2005 *Molec. Ecol*.)
- Ecologically effective population size: sufficient to reproduce historic ecosystem processes and prey behavior (Soule et al. 2003 *Conserv. Biol*.)

Proposed wolf reclassification rule (Defenders v. Norton 2005) enjoined due to:

- Lack of consideration of “significant portion of range”.
- Failure to correctly apply DPS policy

When considered along with 3 similar rulings, implies that future recovery plans should be guided by the concept of significant portion of range as clarified by relevant principles of conservation biology, and a range-wide determination of habitat suitability

- What areas could support fishers?
- How can landscape connectivity be protected to allow future recolonization of unoccupied habitat?
- If reintroduction is necessary, what strategy would be most successful?

The requirement for population viability is a subset of the larger recovery mandate. A single viable population may not represent species recovery, even if large enough to be relatively resilient to extinction.

Five principles of conservation planning can help guide recovery planning

- Representation - establishing populations across the full array of potential habitats
- Resiliency - protecting populations large enough to remain viable
- Redundancy - saving enough copies of those populations that some can be lost without a loss of species
- Ecological effectiveness - restoring enough individuals of a species to restore predation and other ecosystem processes
- Connectivity - protecting linkage areas, especially those that enhance viability by connecting larger with smaller populations