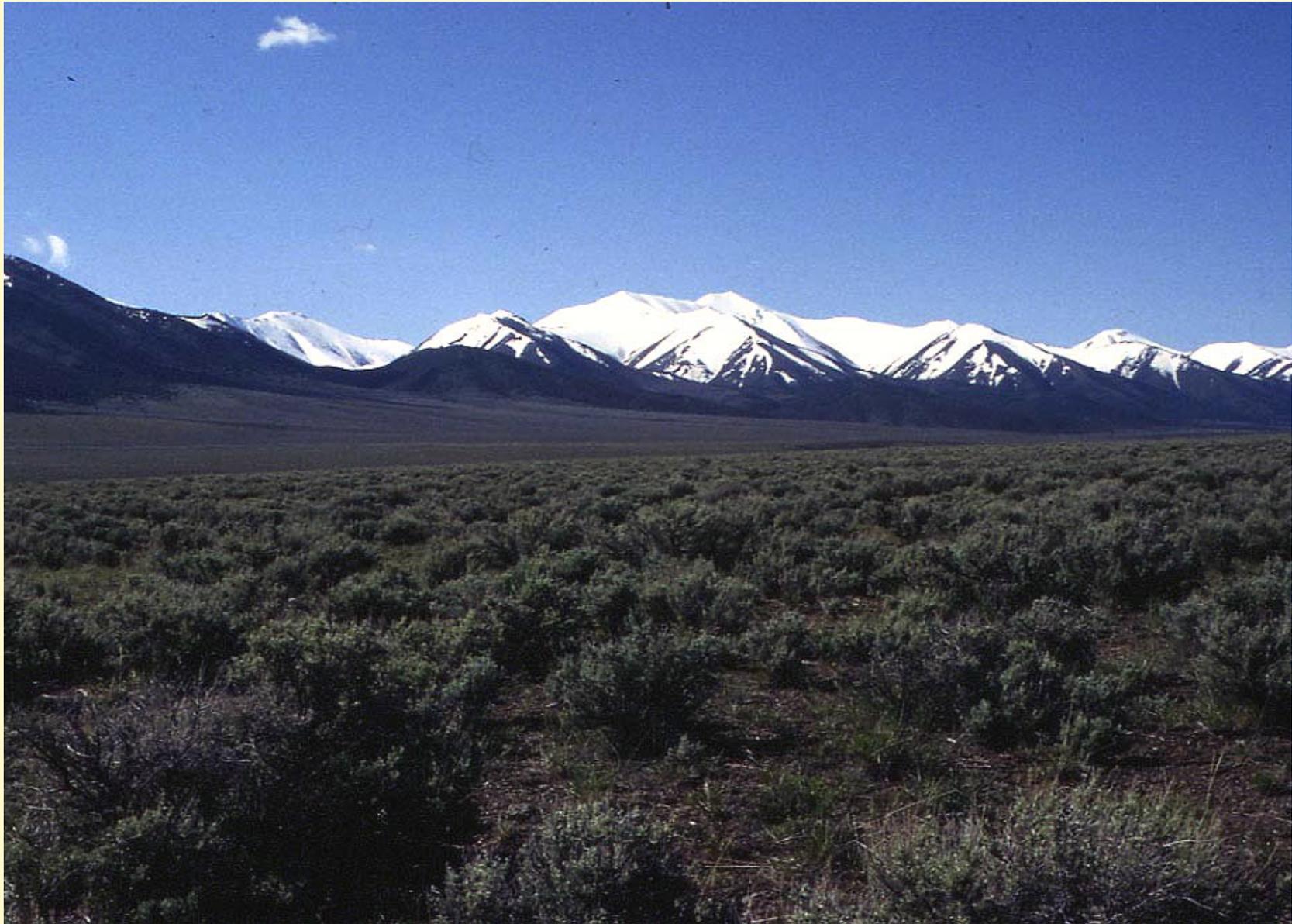




# Application of Science

"No, a thousand times no; there does not exist a category of science to which one can give the name applied science. There are science and the applications of science, bound together as the fruit to the tree which bears it."

Louis Pasteur, 1871



# Expansion of Pinyon–Juniper Woodland



# Non-native Invasive Species



native shadscale and bunchgrasses

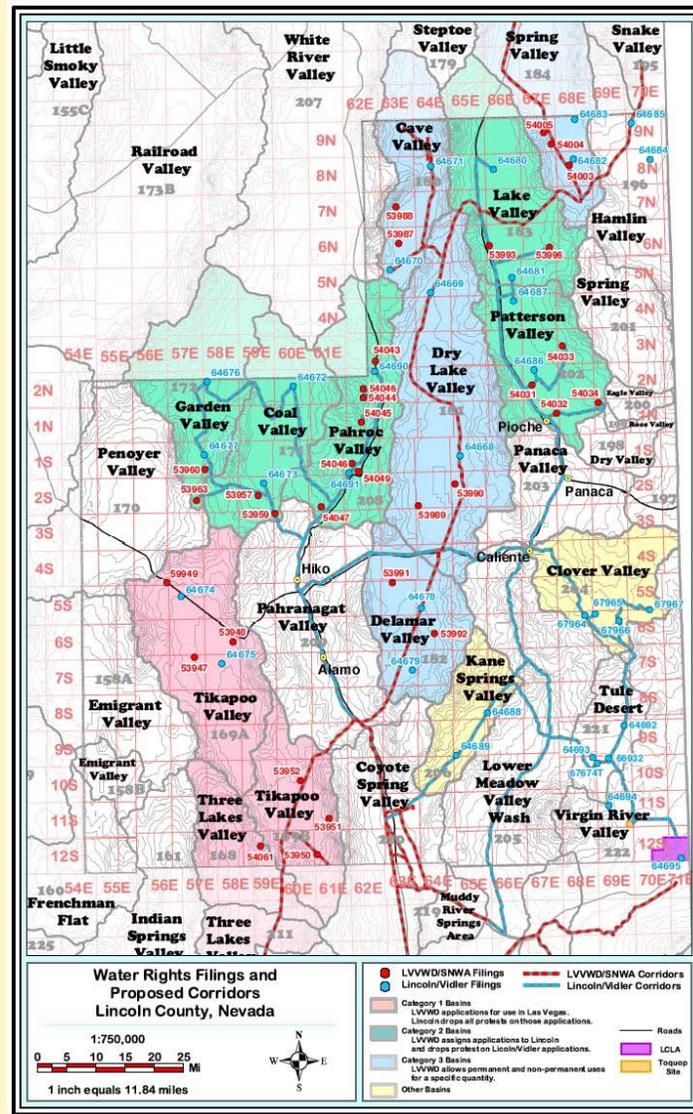
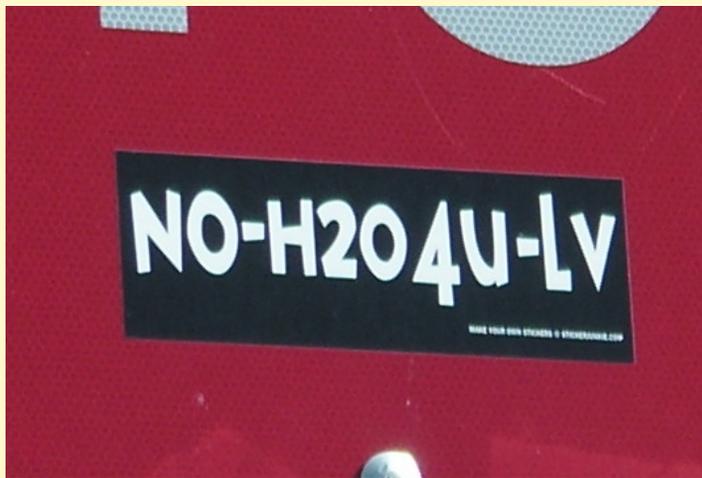


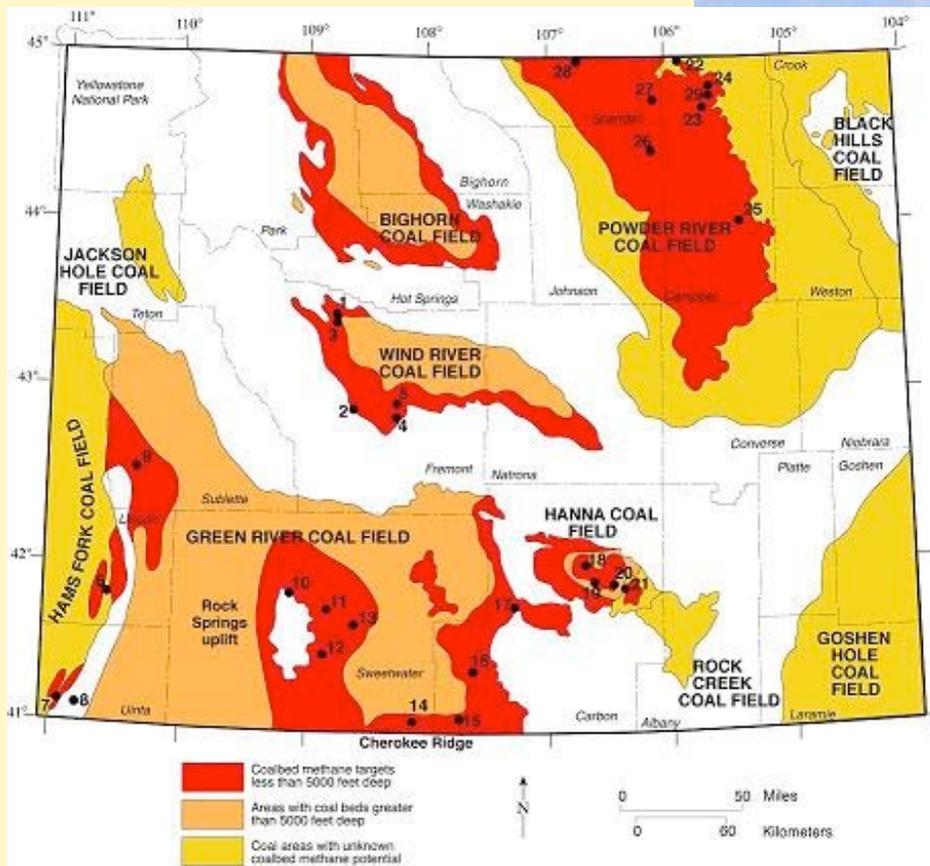
cheatgrass (*Bromus tectorum*)

# Exurbanization



# Lincoln County Conservation, Recreation and Development Act





Can intervention influence the outcome?



# From Persistence to Connectivity

- Persistence: amount and condition of a species' habitat
- Fragmentation leads to considering connections in space and time
- Maximize quality and connectivity for multiple species



# Landscape Connectivity



- Ecosystem-level property that reflects the influence of landscape structure on a species' mobility and its probability of survival within and among resource patches
- Propagation through space of ecological processes (e.g., flows)

# Representations of Connectivity



- Binary map of habitat / nonhabitat
- Continuous surface of movement cost
- Maps of land-cover and stressors that have different effects at different life stages

# Connectivity is Dynamic

- Throughout a species' life history
- In response to changing environmental conditions
- Especially important for species that use different sets of resources
- Spatial, temporal scale depends on the species



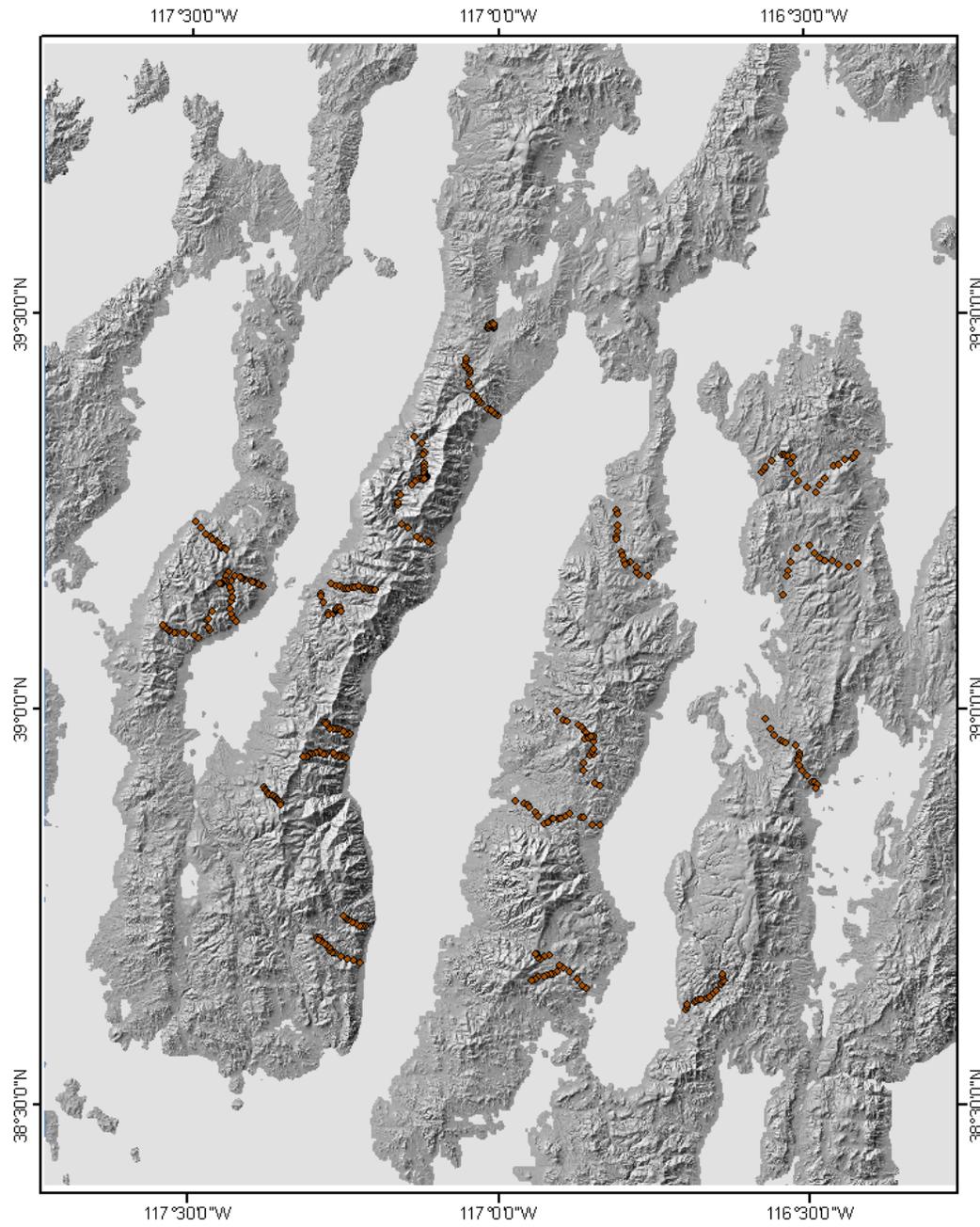
# Aims

- Proof of concept for modeling approach
- Explore potential effects of changes in land cover and climate on distributions of breeding birds
- Identify locations with high probabilities of occupancy under a range of possible future conditions



many years (10)  
many locations (~400)  
fixed-radius point counts





bird  
data

habitat  
data

◀ build  
models

▶ new bird  
data

▶ validate  
models

topography,  
land cover,  
climate



bird  
data

habitat data improved model fit  
did not improve cross-validation results

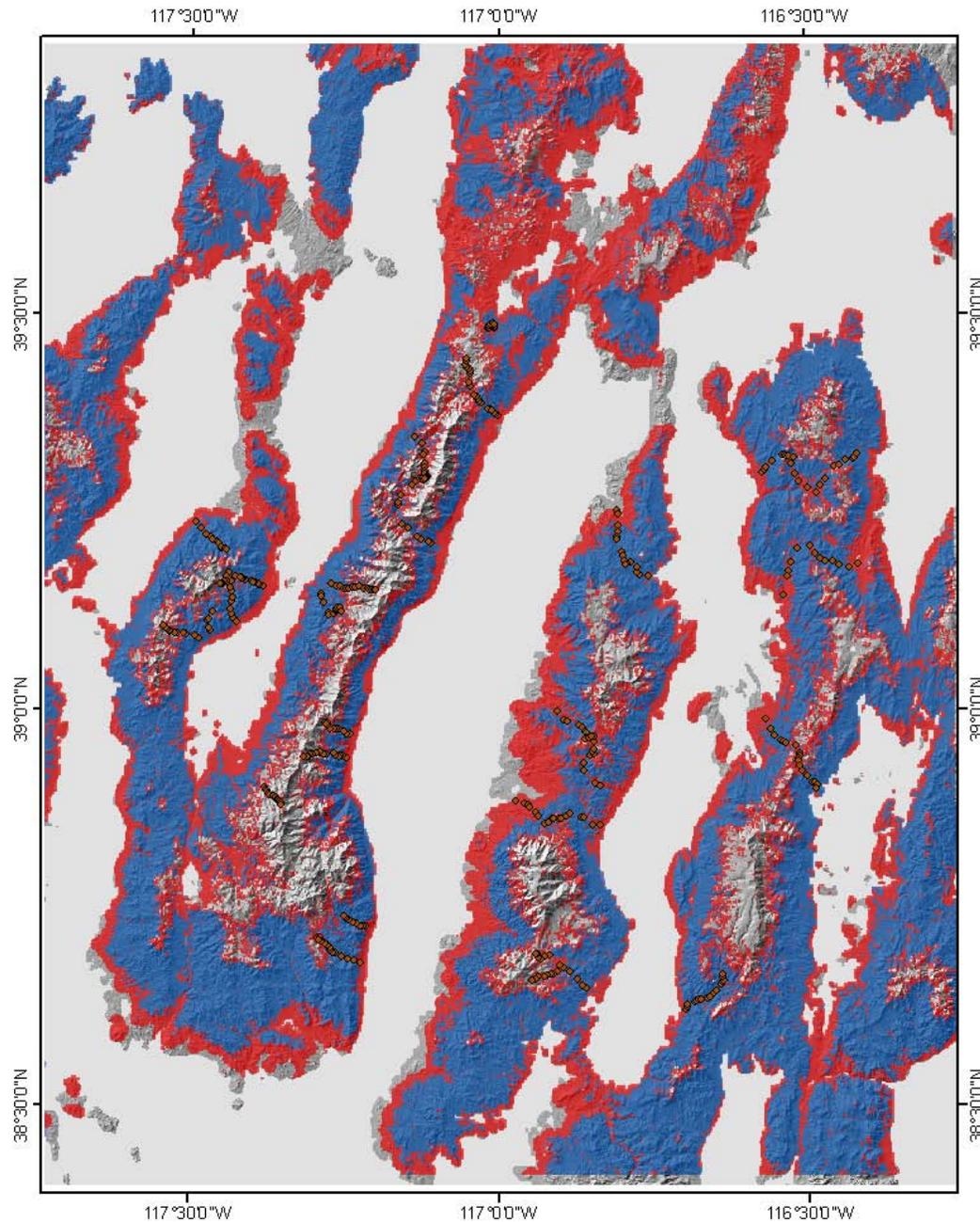


topography,  
land cover,  
climate



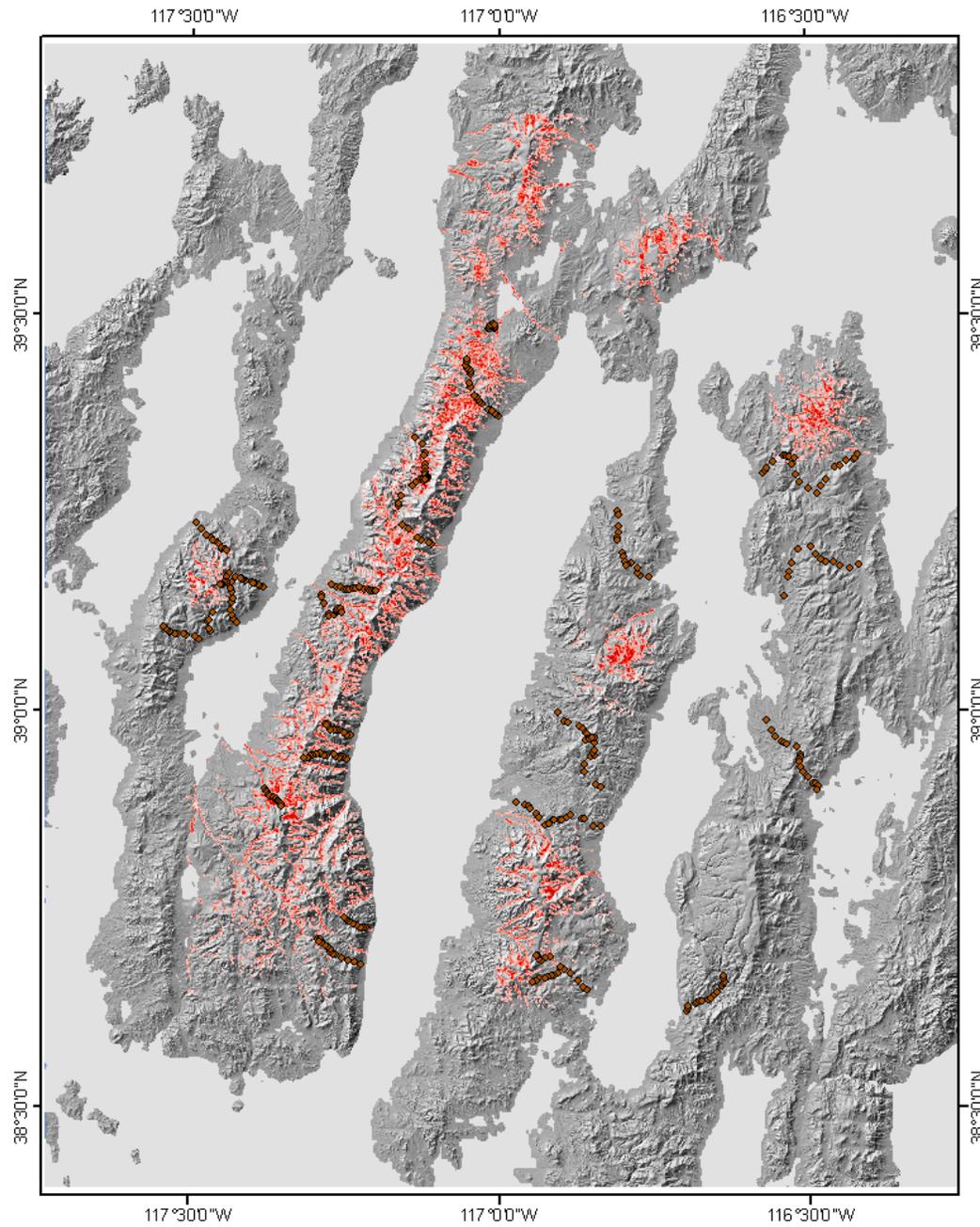
Relative proportion of variance in occurrence explained by different variables (mean across species, not all variables shown, slightly different results if field measurements included)

<b>variable</b>	<b>mean variation explained</b>
Riparian cover	13.2
Elevation	12.4
Slope	11.7
Pinyon and juniper cover	9.8
Total canopy cover	9.7
Precipitation	8.8
Minimum temperature	8.8



Scenario 1: expansion of pinyon-juniper woodlands

Based on Bradley (2010). Pinyon-juniper in areas with maximum probability of expansion of 20% by 2100. Replaces sagebrush, does not replace riparian.



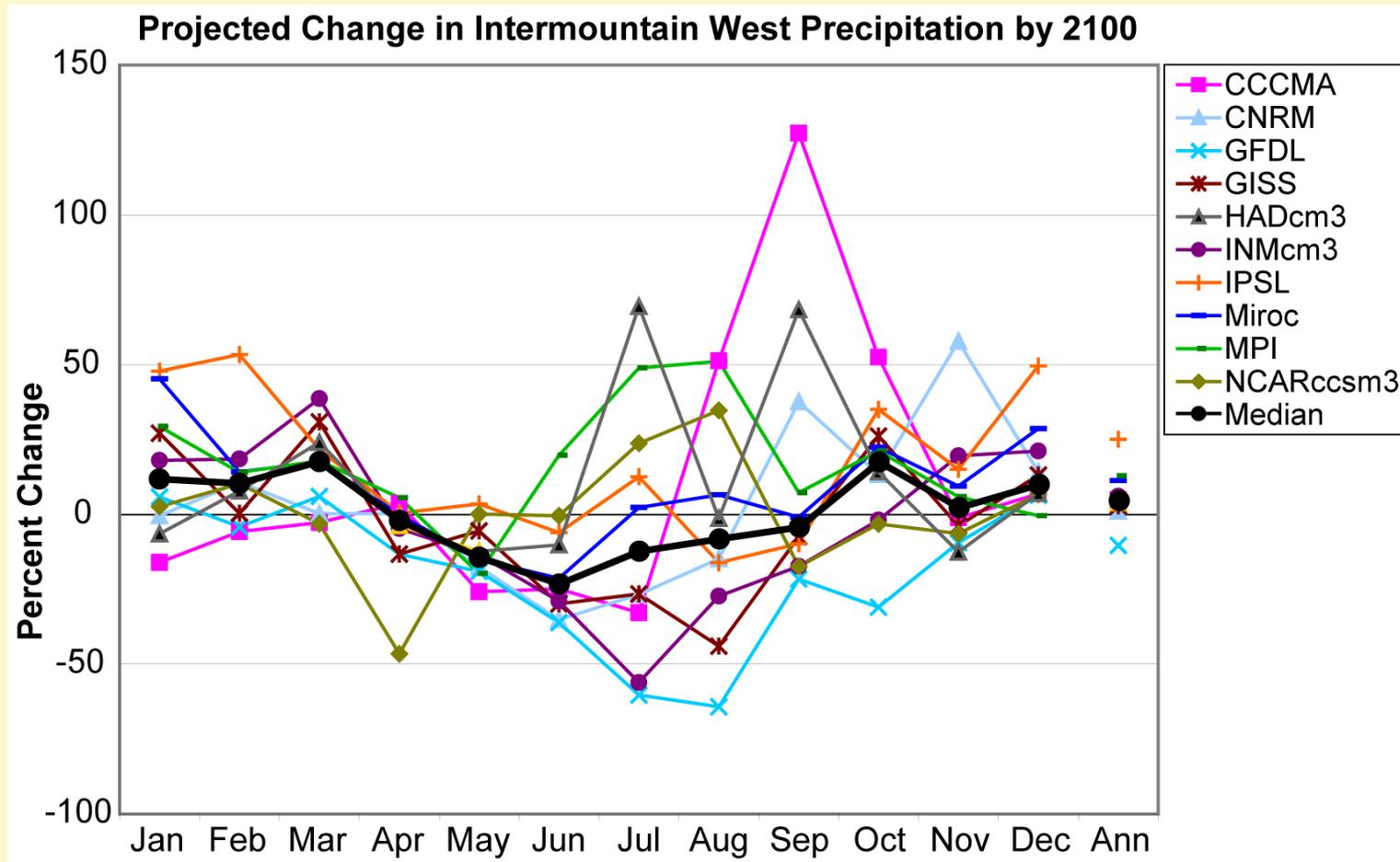
Scenario 2: contract  
extent of riparian  
cover by 10%

Color intensity  
proportional to  
percent cover lost

### Scenario 3: Precipitation change

Mean annual increase of 4% (median of ensemble of 10 general circulation models)

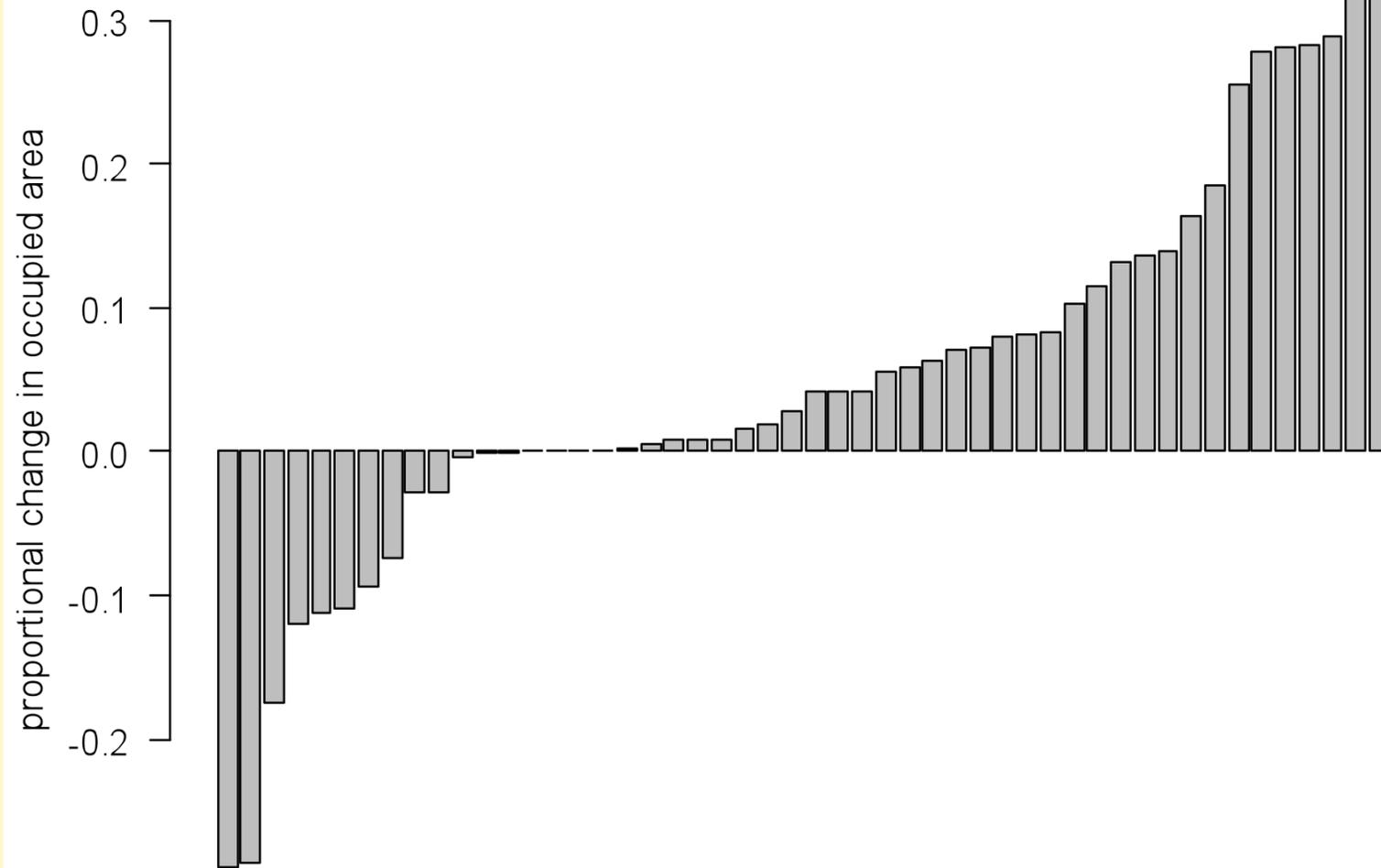
Mean annual decrease of 10% (maximum decrease)



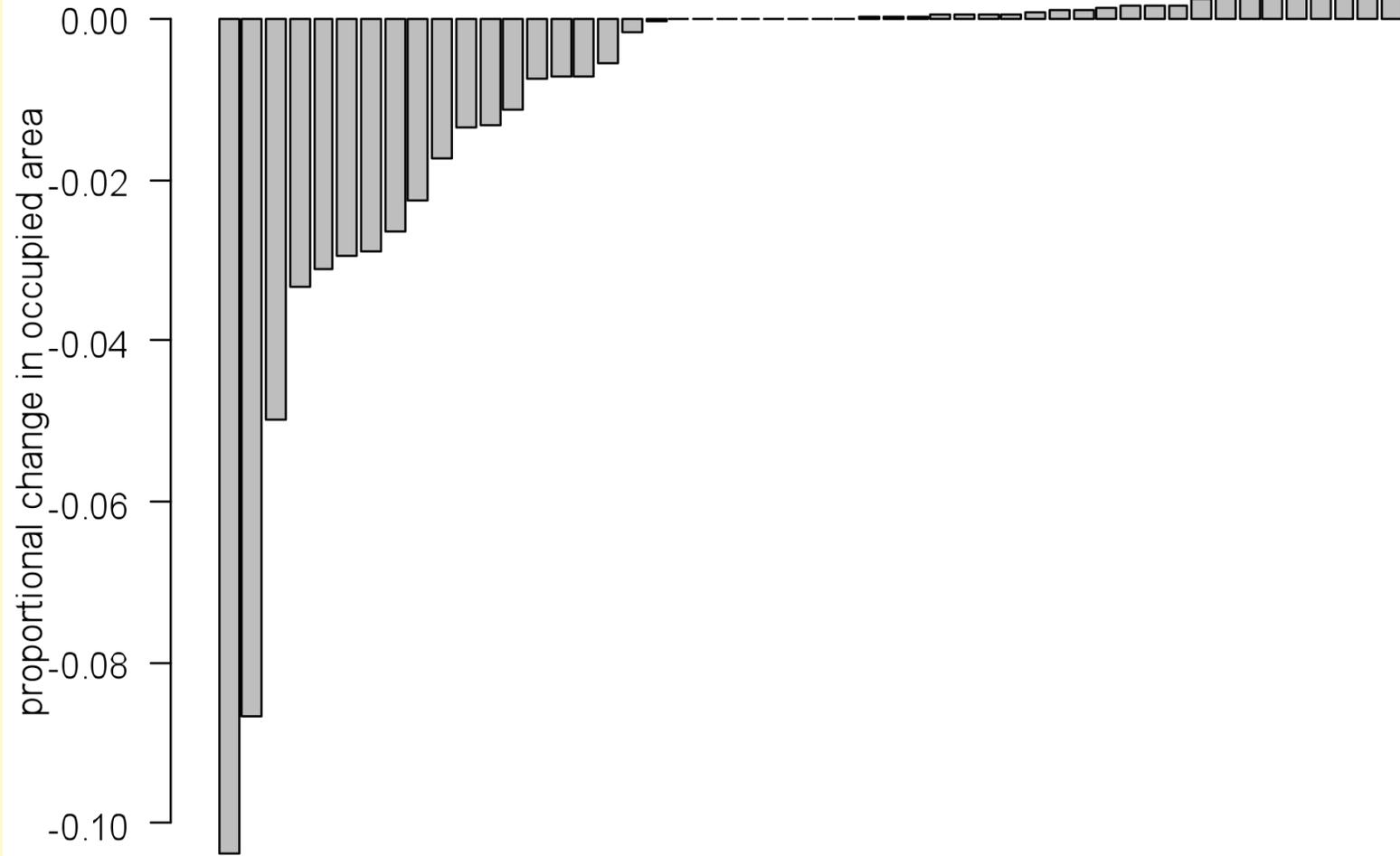
courtesy Bethany Bradley

# Zonation

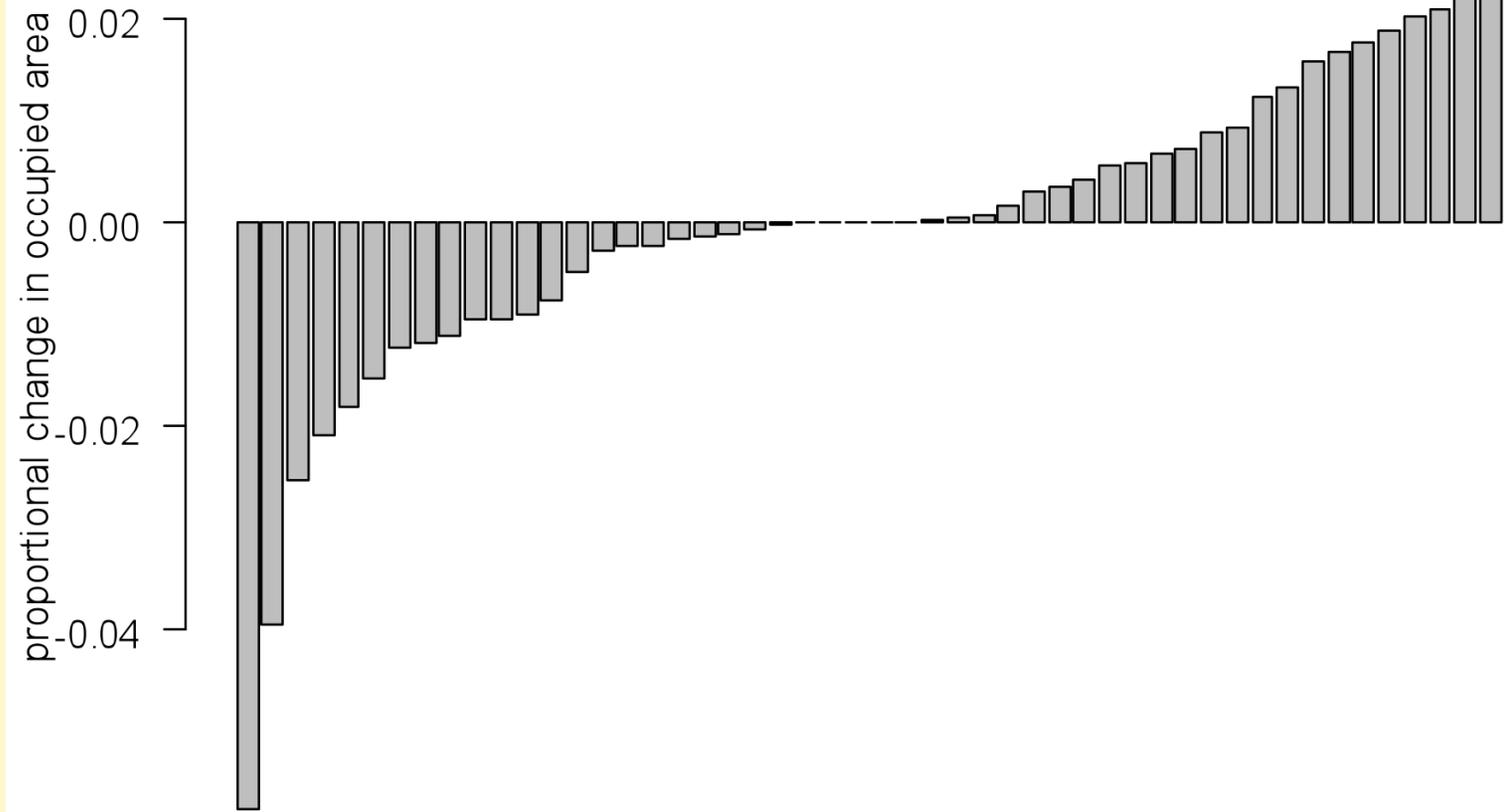
- Tool for spatially explicit conservation planning
- Identify areas with high probability of occurrence of multiple species, accounting for each species' resource requirements
- Ranks grid cells based on projected probabilities of occurrence of all species
- If a location represents high proportion of occupied area for any one species, it generally will be ranked highly



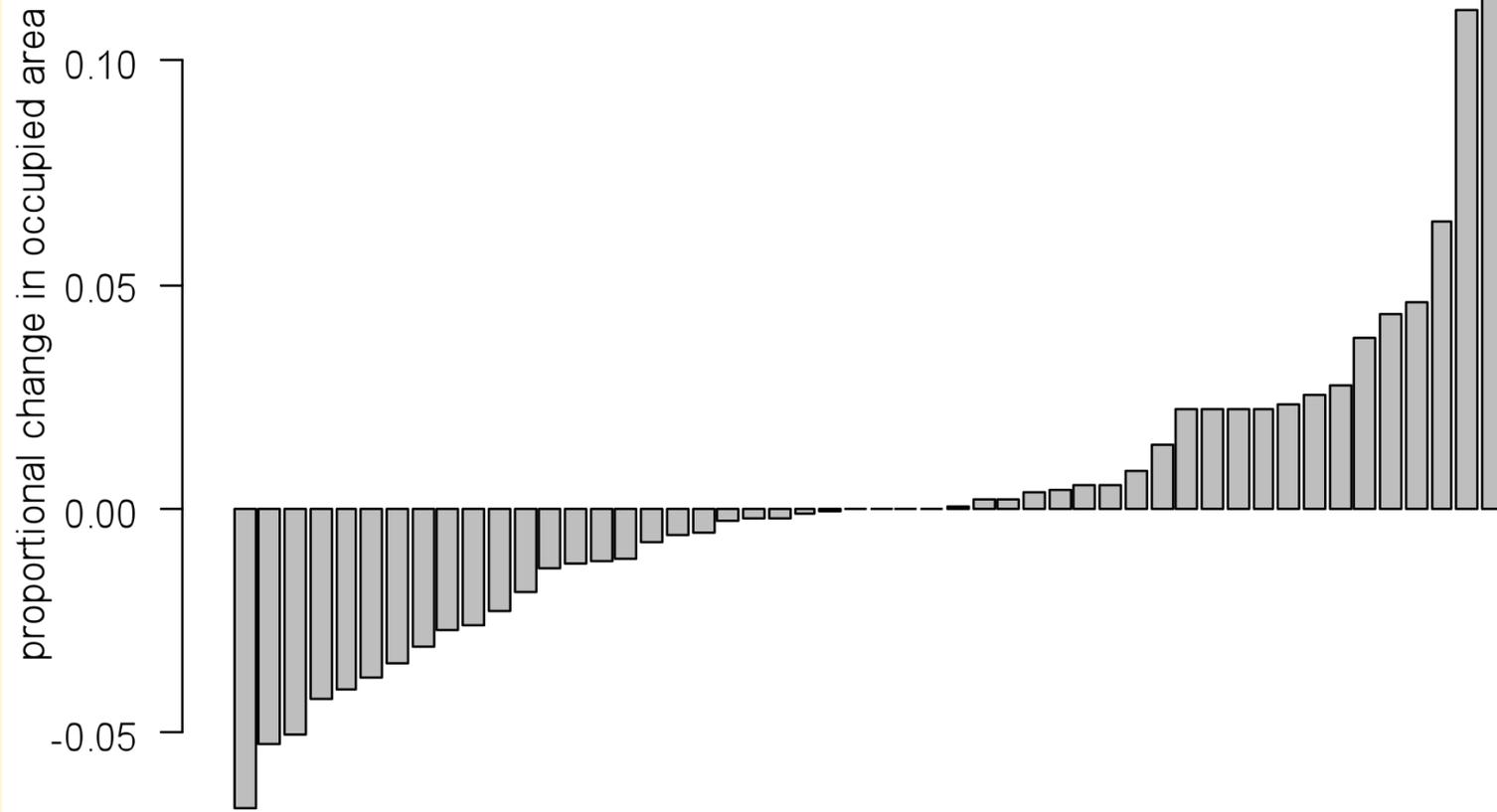
Proportional change in probabilities of occurrence for species of breeding birds if pinyon and juniper woodlands expand as projected



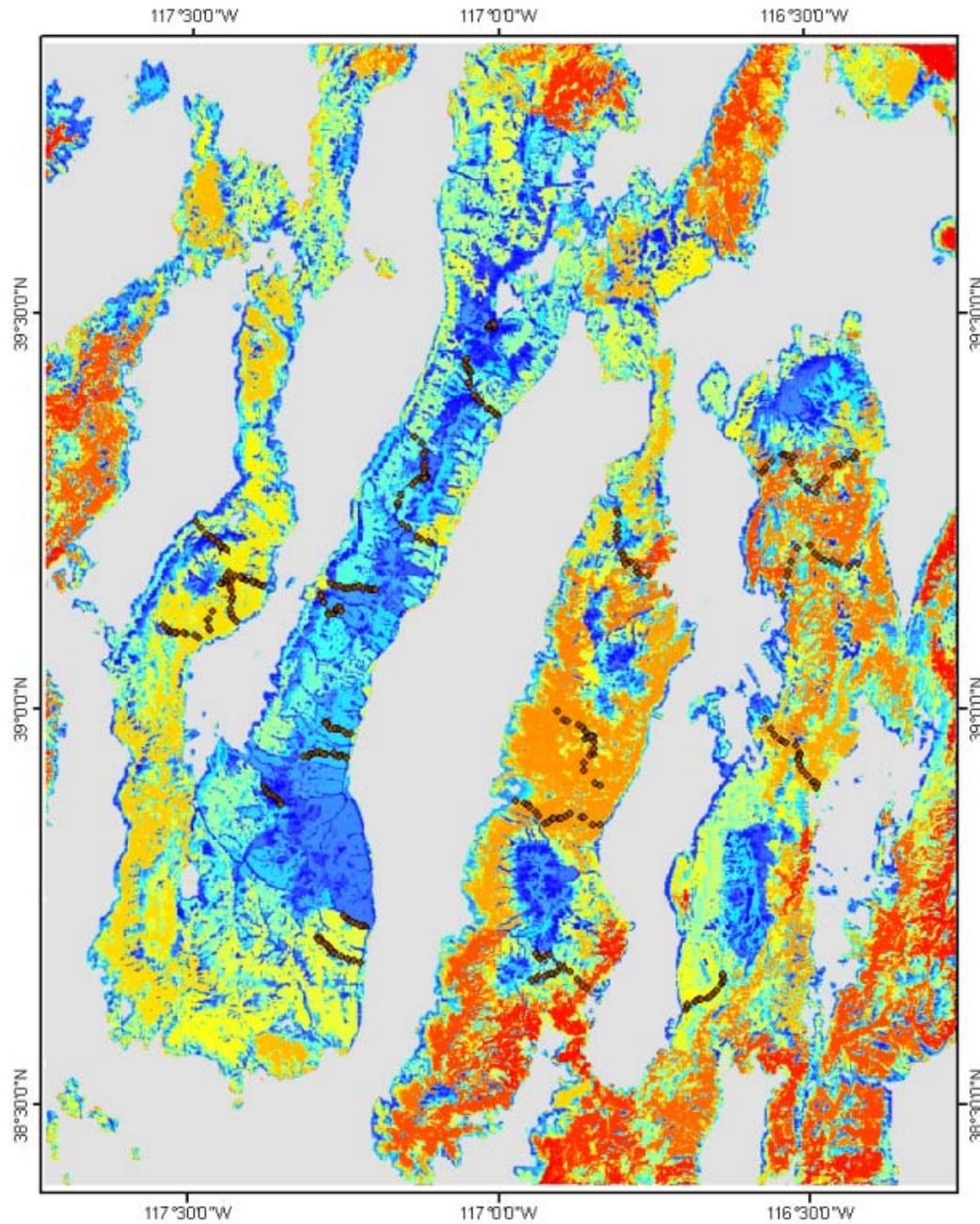
Proportional change in probabilities of occurrence for species of breeding birds if riparian areas contract



Proportional change in probabilities of occurrence for species of breeding birds if precipitation increases 4%

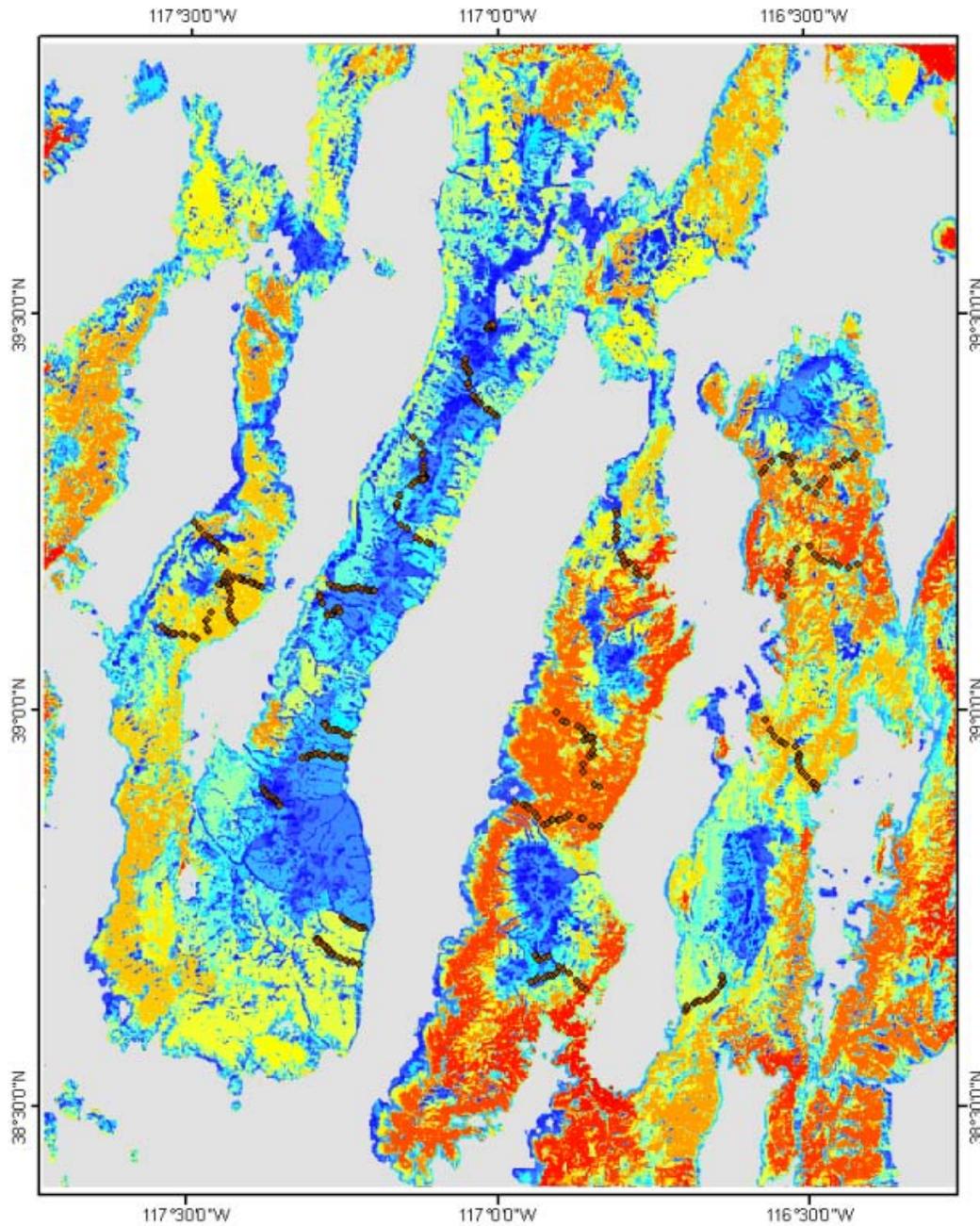


Proportional change in probabilities of occurrence for species of breeding birds if precipitation decreases 10%



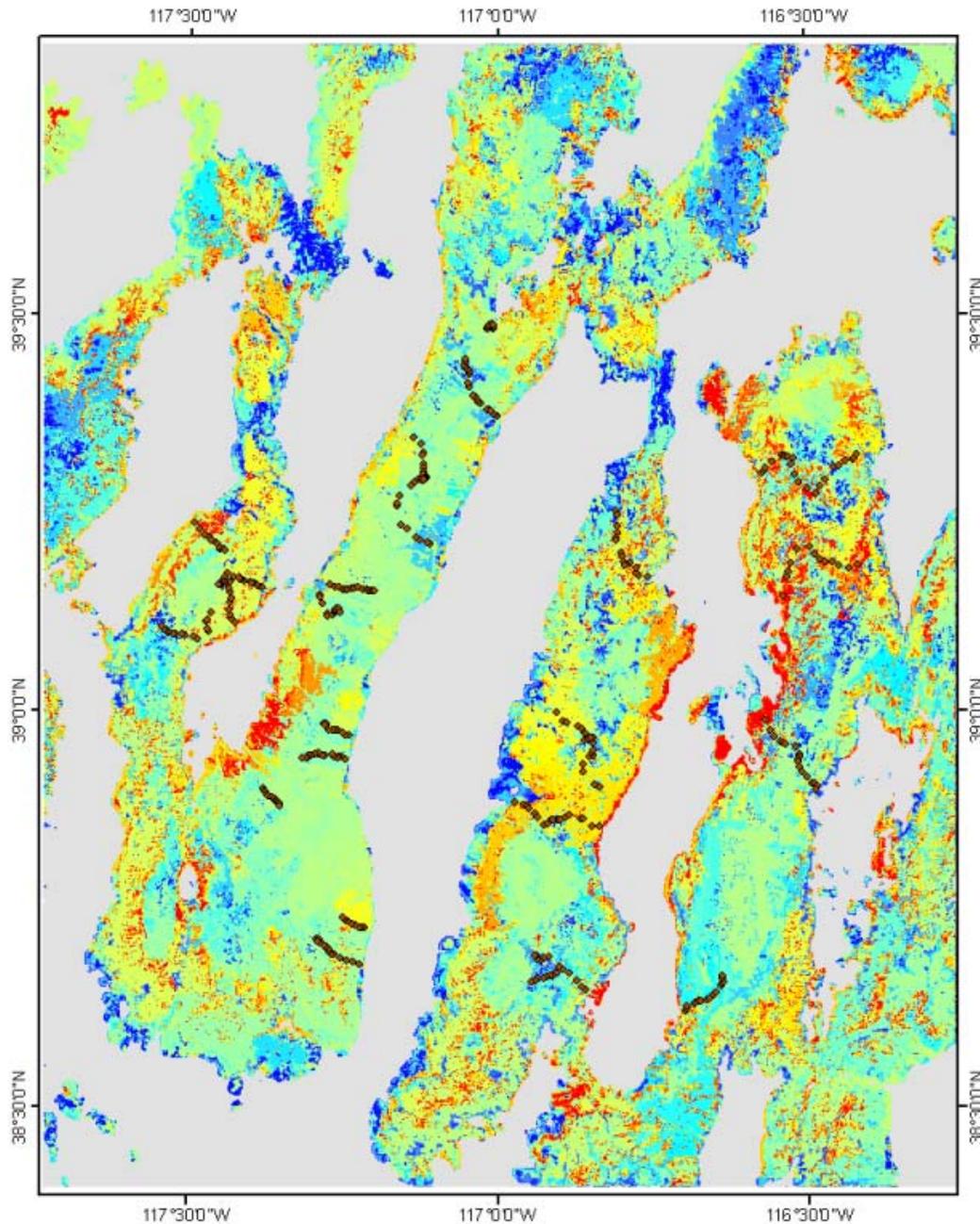
All species of  
breeding birds

Current  
probabilities of  
occurrence



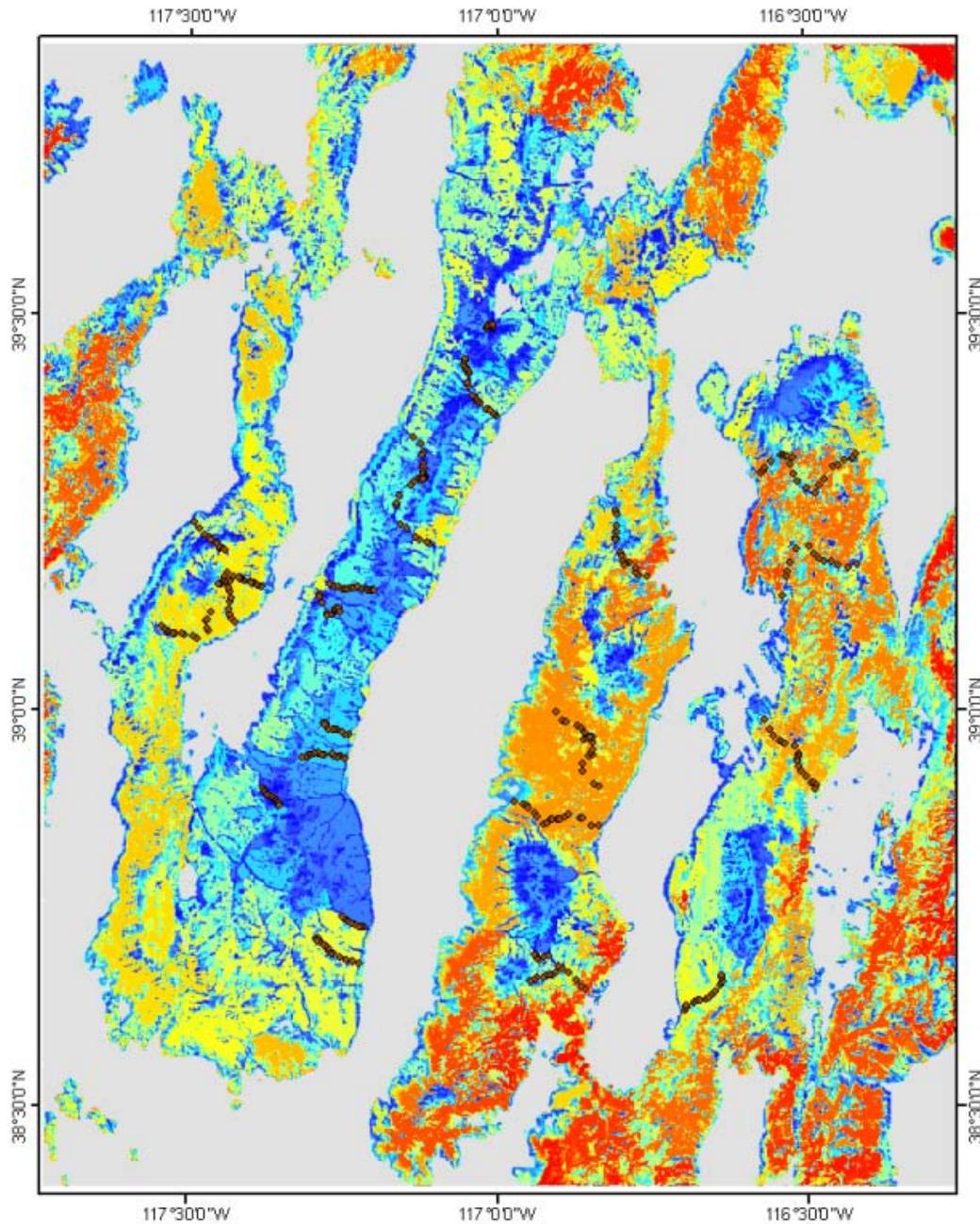
All species of  
breeding birds

Future probabilities  
of occurrence if  
pinyon-juniper  
woodlands expand  
as projected



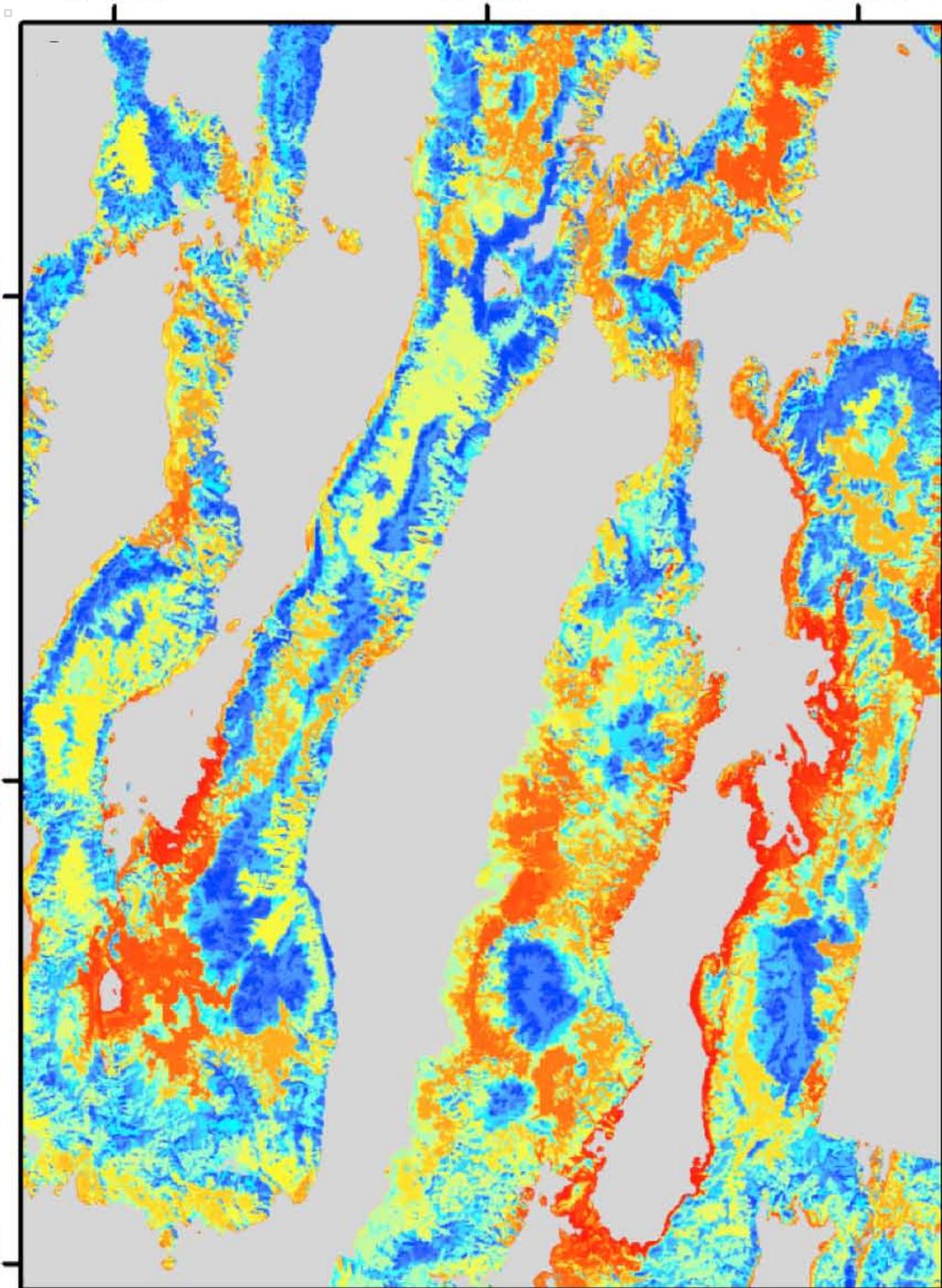
All species of  
breeding birds

Changes in  
probabilities of  
occurrence (blue =  
increase, red =  
decrease) if pinyon-  
juniper woodlands  
expand as  
projected



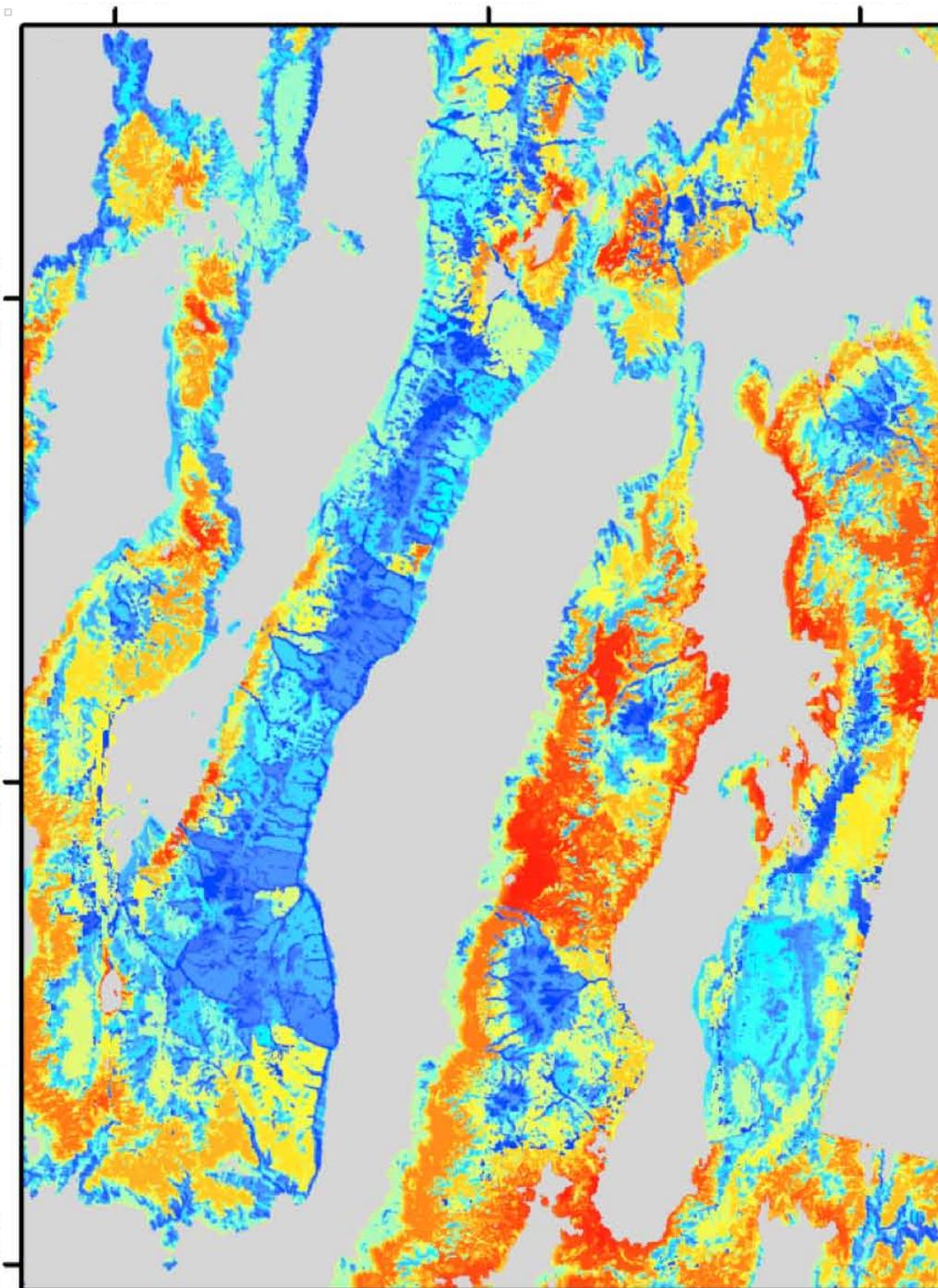
All species of  
breeding birds

Locations with  
persistently high  
probabilities of  
occurrence if  
pinyon-juniper  
woodlands expand  
as projected



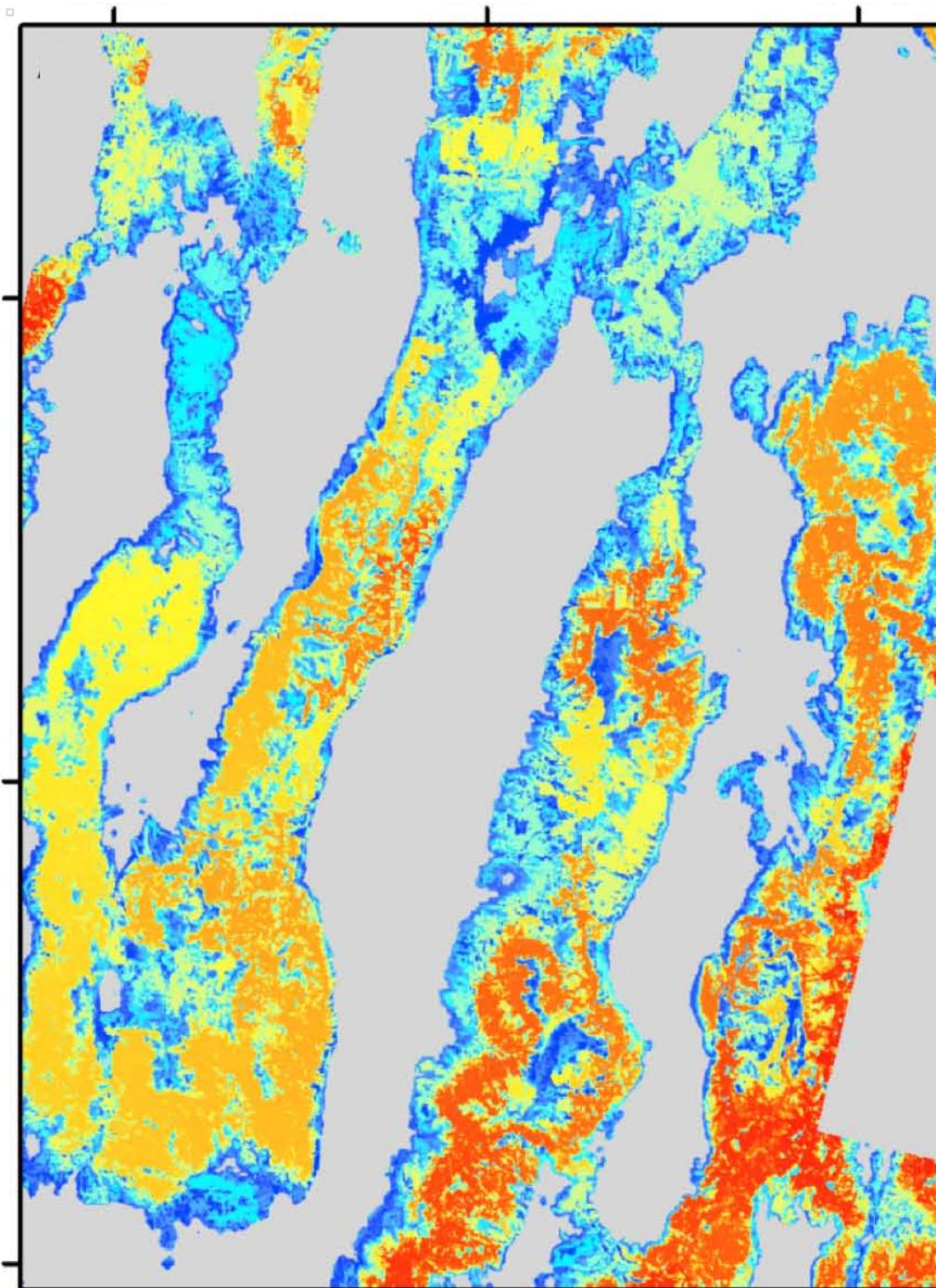
Species associated  
with pinyon and  
juniper

Current  
probabilities of  
occurrence



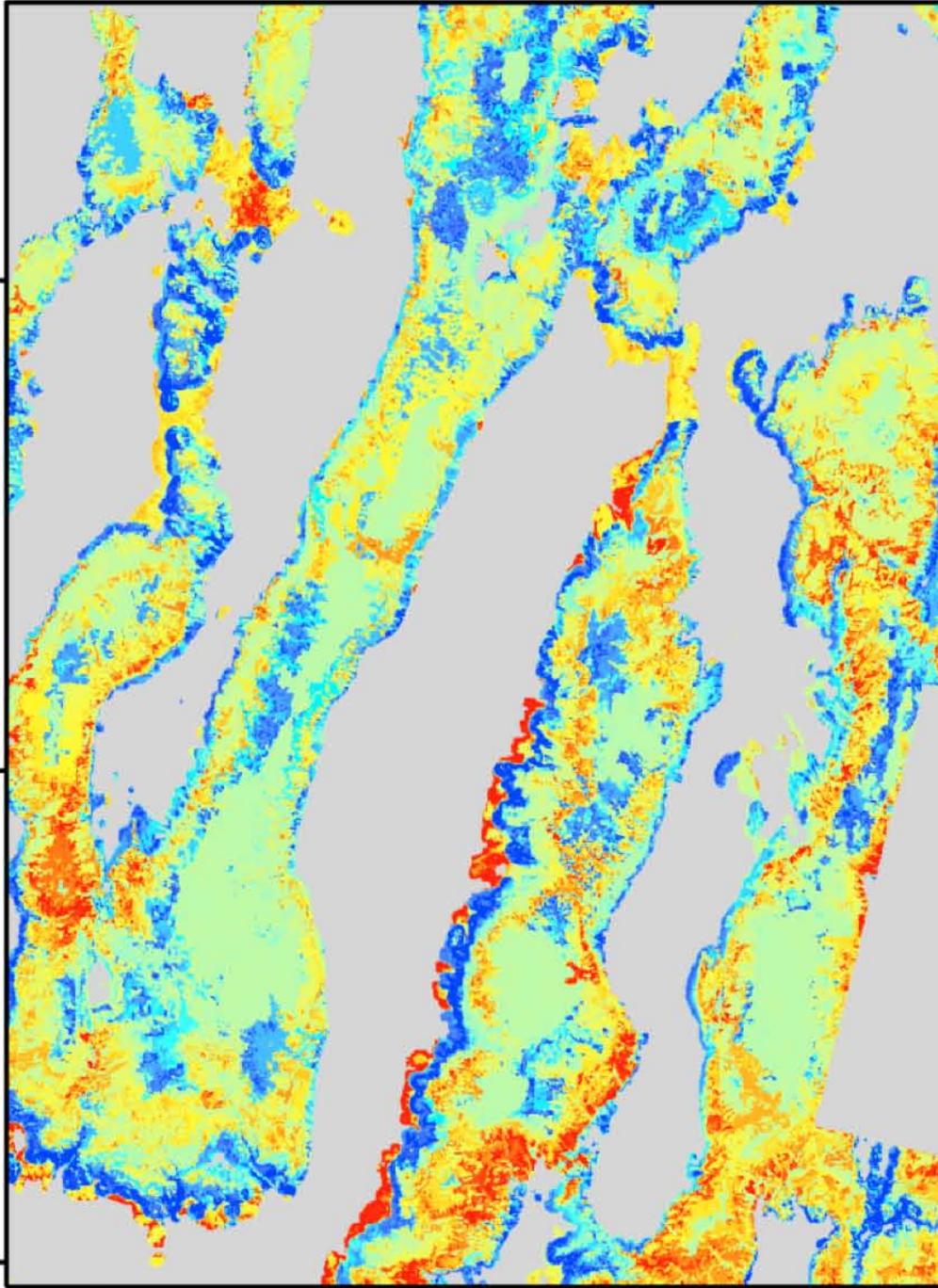
Species associated  
with riparian areas

Current  
probabilities of  
occurrence



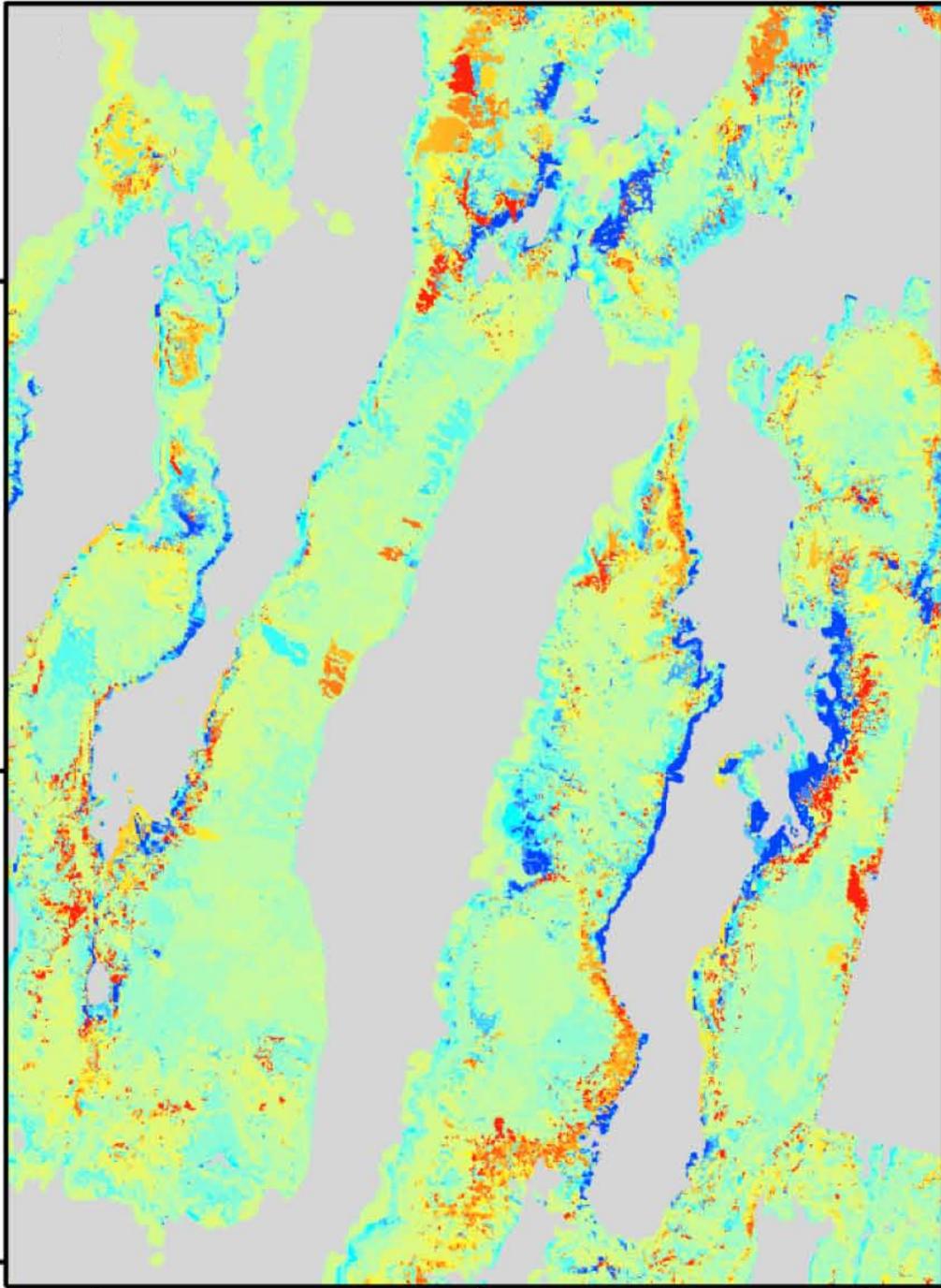
Species associated  
with sagebrush

Current  
probabilities of  
occurrence



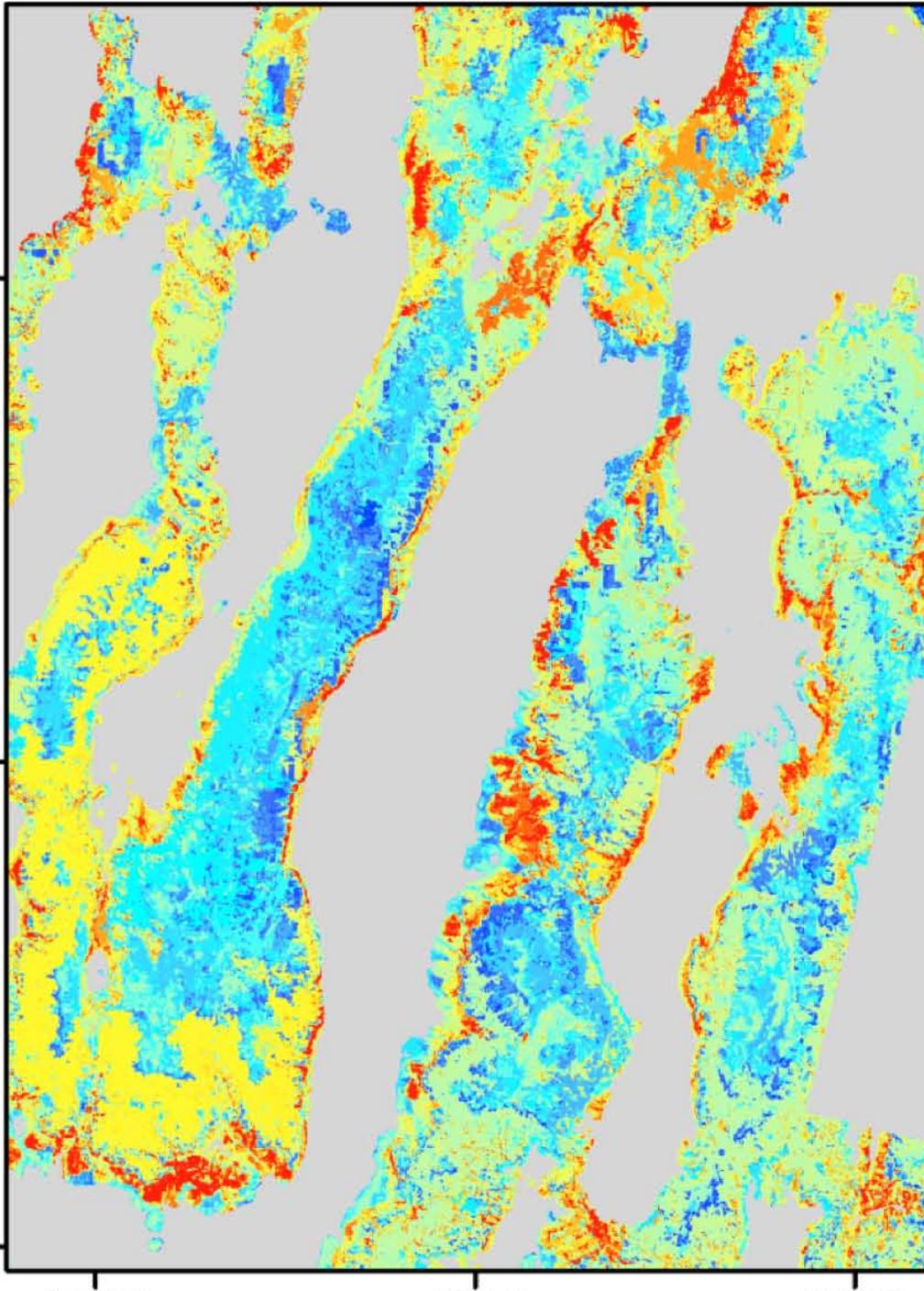
Species associated  
with pinyon and  
juniper

Changes in  
probabilities of  
occurrence if  
pinyon-juniper  
woodlands expand



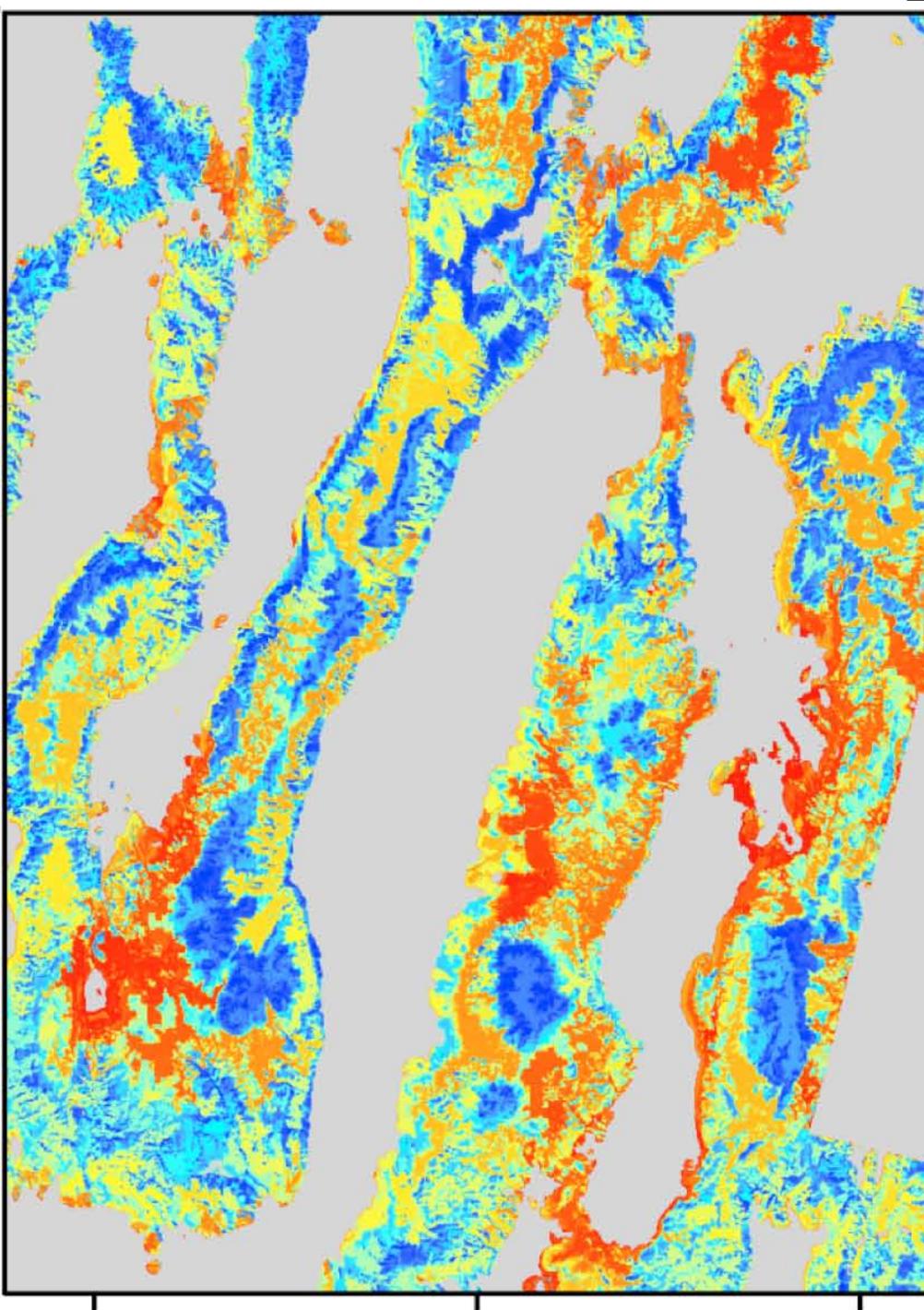
Species associated  
with riparian areas

Changes in  
probabilities of  
occurrence if  
pinyon-juniper  
woodlands expand



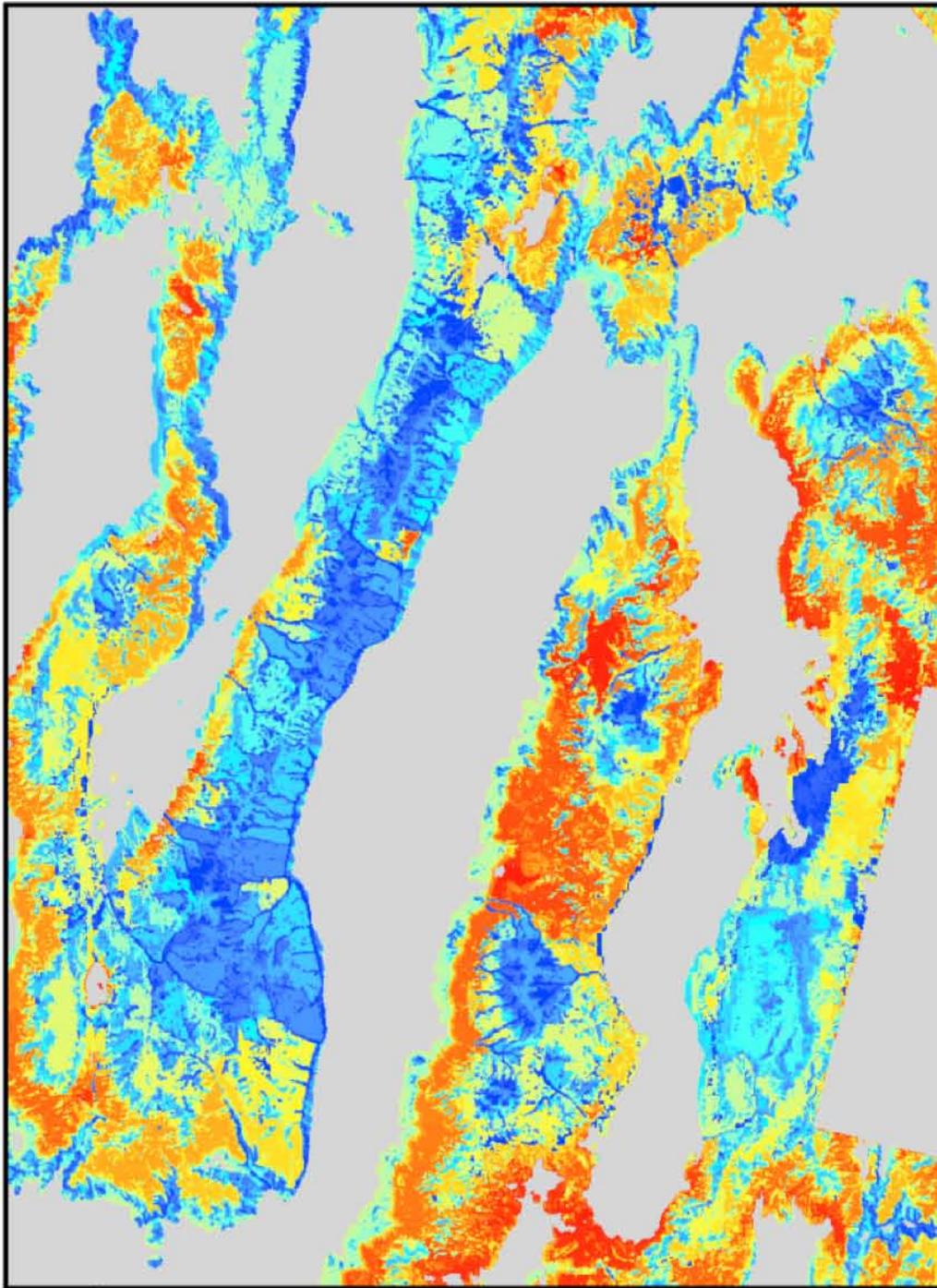
Species associated  
with sagebrush

Changes in  
probabilities of  
occurrence if  
pinyon-juniper  
woodlands expand



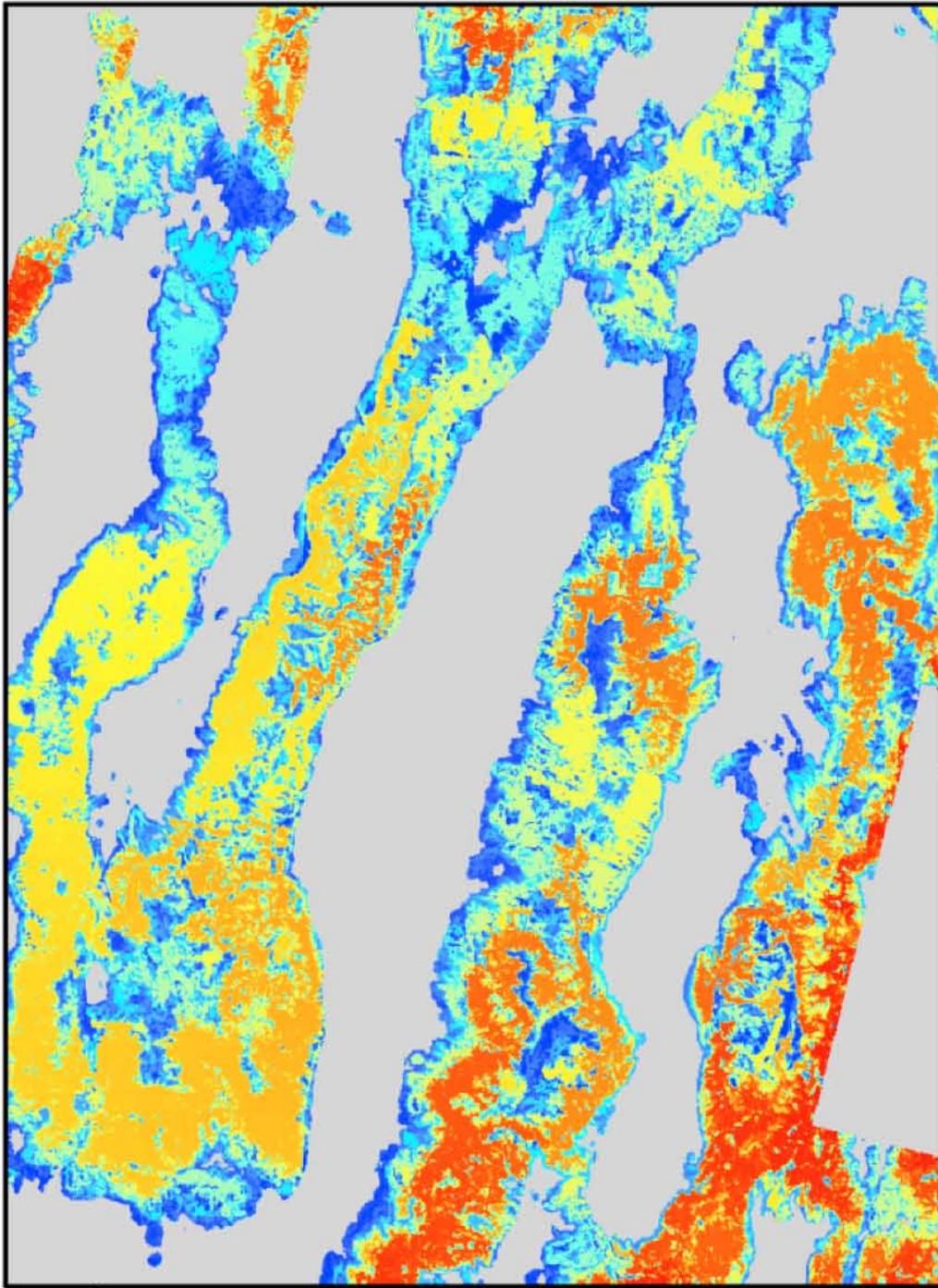
Species associated  
with pinyon and  
juniper

Locations with  
persistently high  
probabilities of  
occurrence



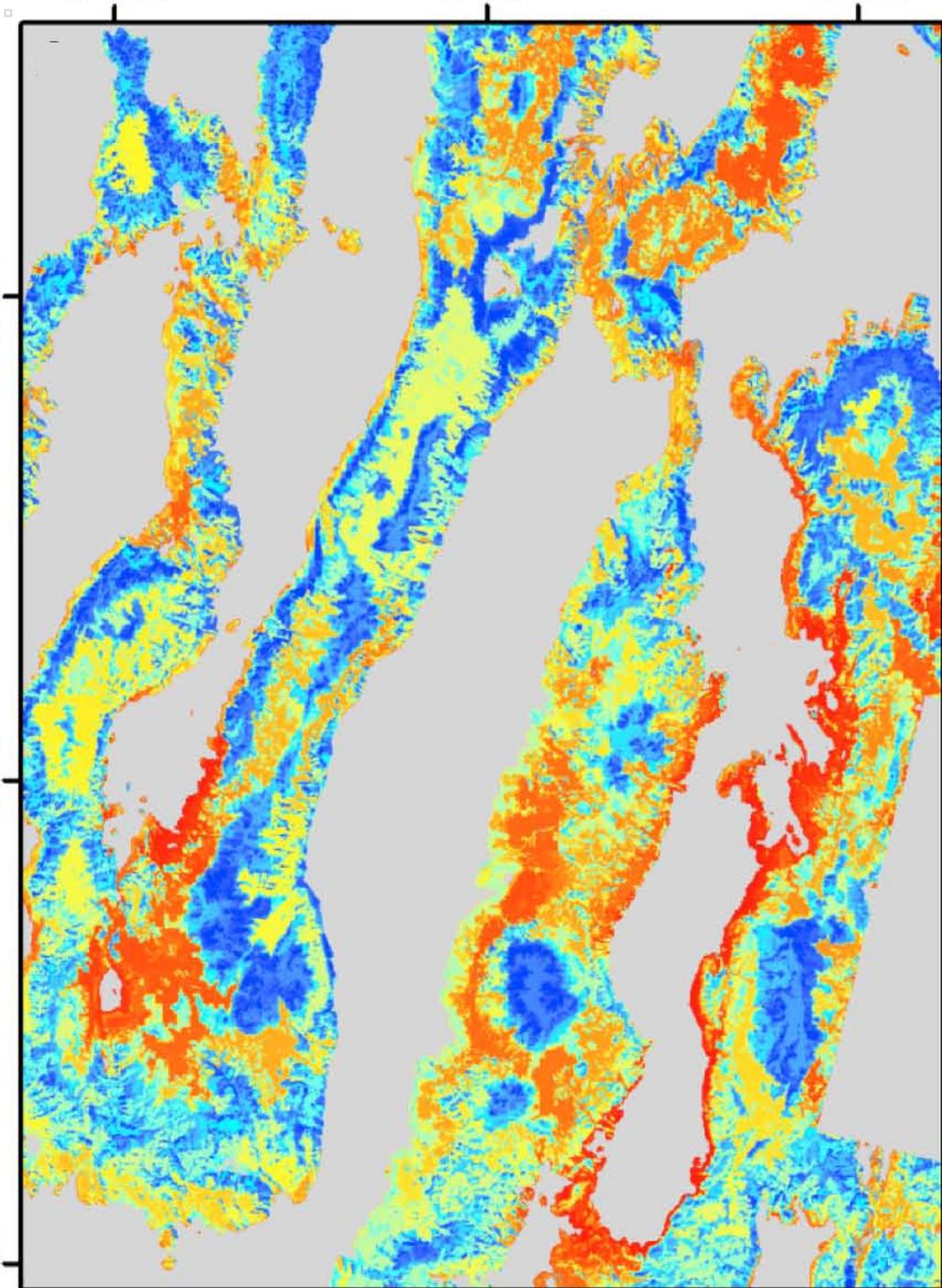
Species associated  
with riparian areas

Locations with  
persistently high  
probabilities of  
occurrence



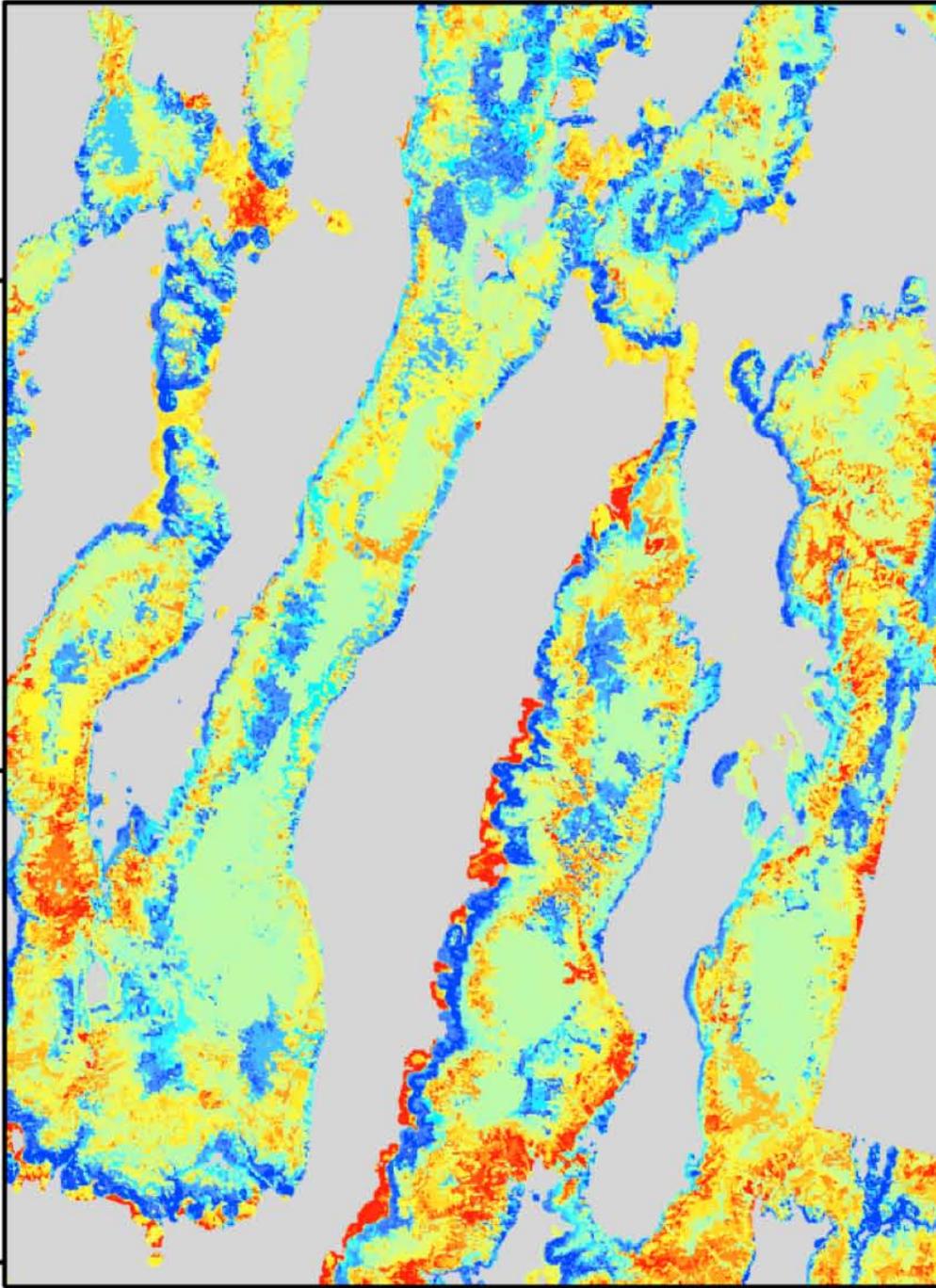
Species associated  
with sagebrush

Locations with  
persistently high  
probabilities of  
occurrence



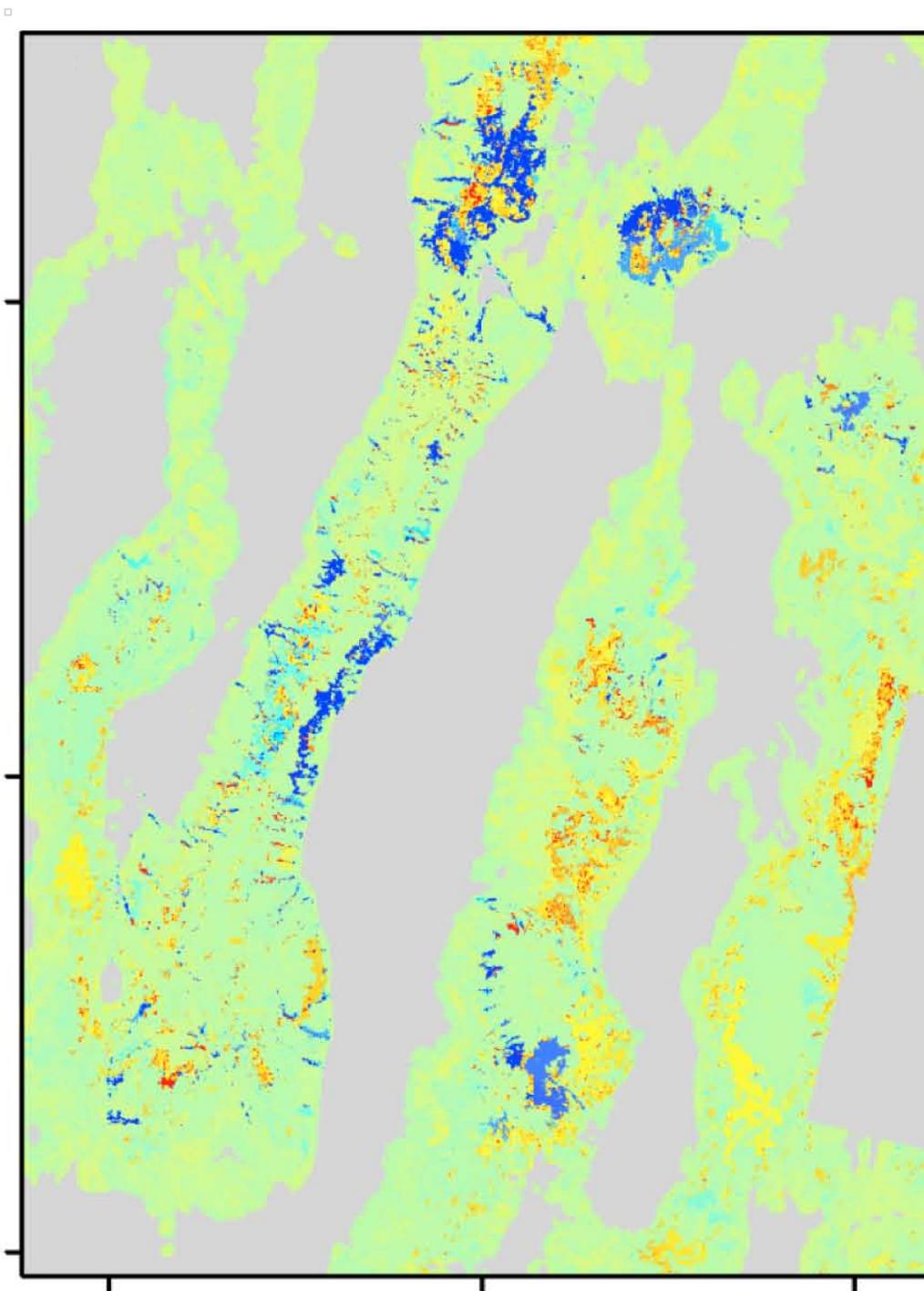
Species associated  
with pinyon and  
juniper

Current  
probabilities of  
occurrence



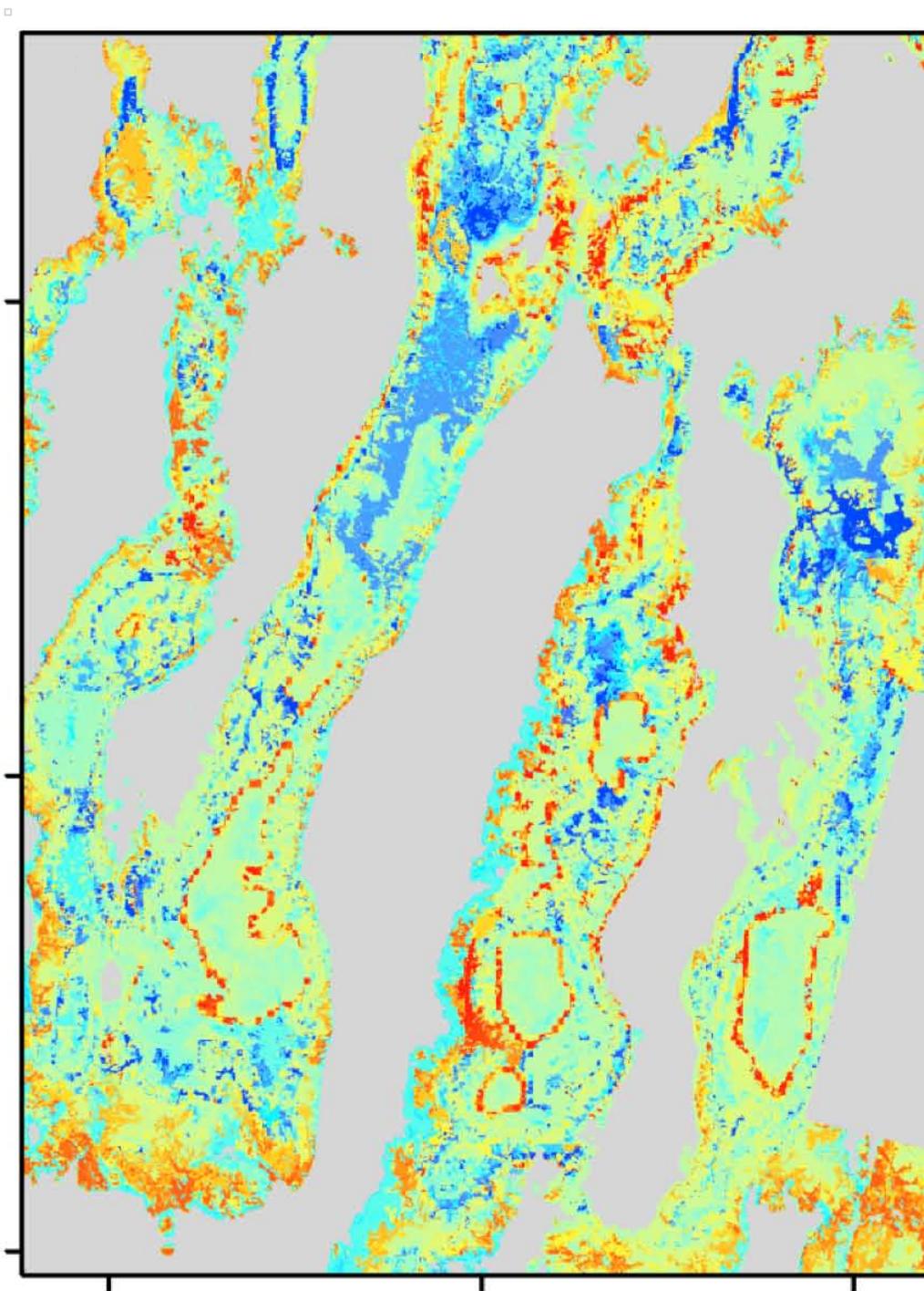
Species associated  
with pinyon and  
juniper

Pinyon-juniper  
expansion:  
changes in  
probabilities of  
occurrence



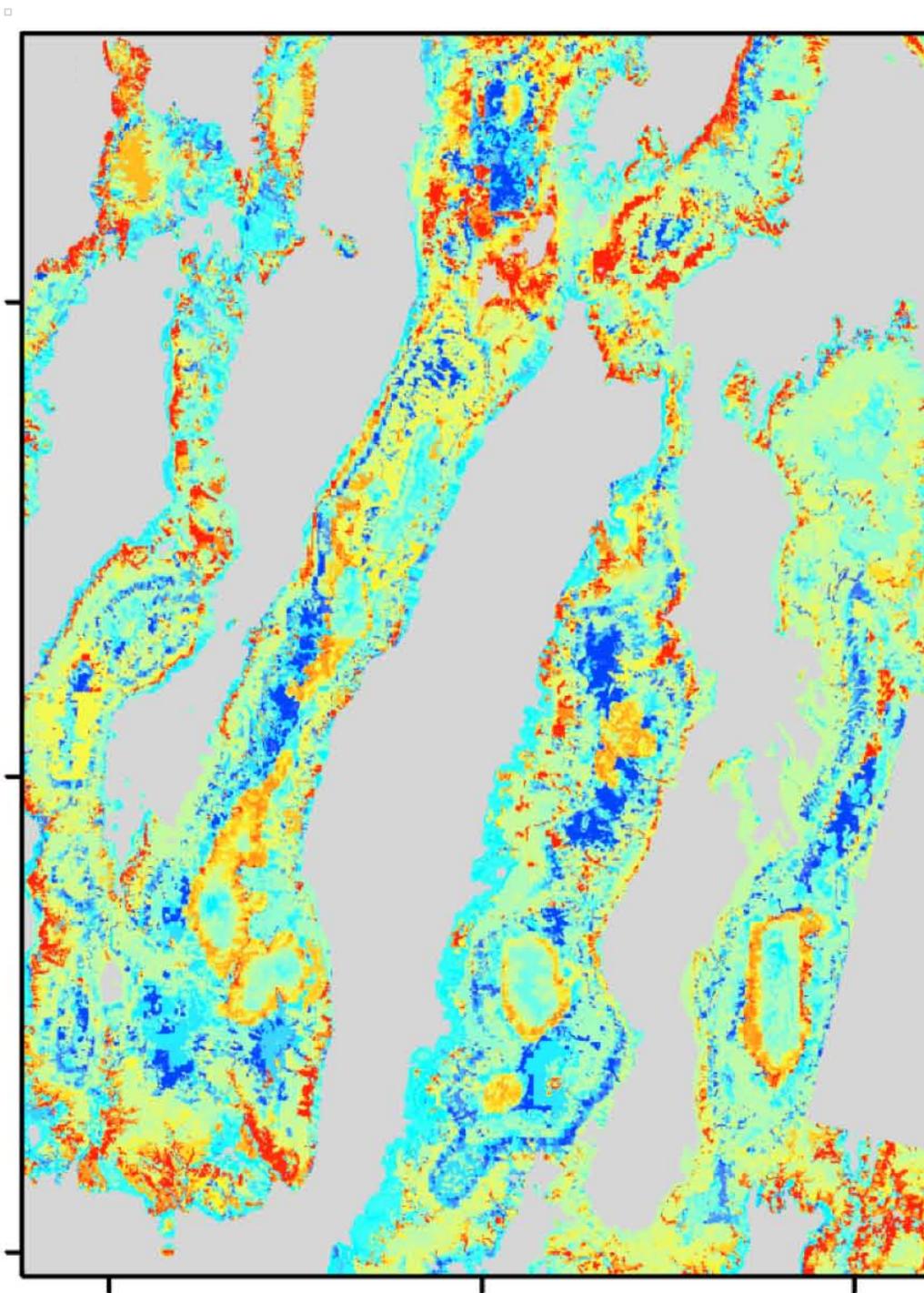
Species associated  
with pinyon and  
juniper

Riparian  
contraction:  
changes in  
probabilities of  
occurrence



Species associated  
with pinyon and  
juniper

Increased  
precipitation:  
changes in  
probabilities of  
occurrence



Species associated  
with pinyon and  
juniper

Decreased  
precipitation:  
changes in  
probabilities of  
occurrence

“It of course goes without saying that economic feasibility limits the tether of what can or cannot be done for the land. It always has and it always will . . . [but the] bulk of all [management success] hinges on investments of time, forethought, skill, and faith rather than on investments of cash.”

Aldo Leopold