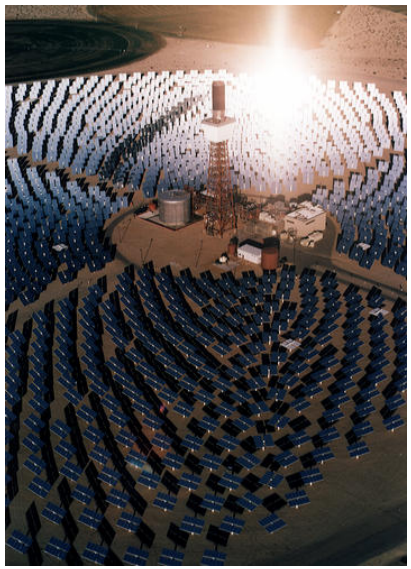
Energy by Design: Blending Landscape Level Planning & The Mitigation Hierarchy



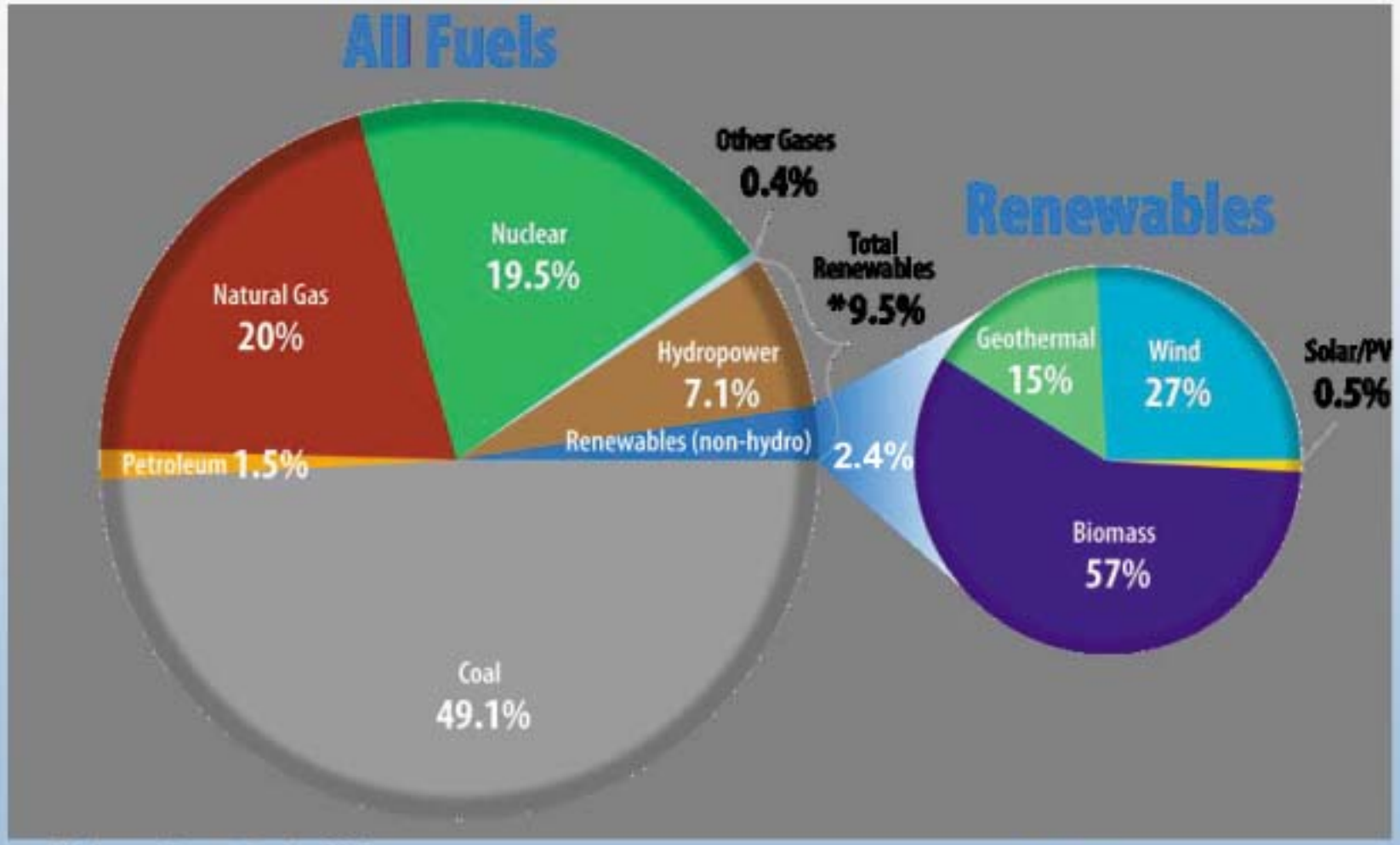
Joseph Kiesecker
Director of Science
The Nature Conservancy
jkiesecker@tnc.org

April 9, 2008

The Nature Conservancy
Protecting nature. Preserving life.™

What Are the Major Renewables?

Electricity Net Generation – 2006

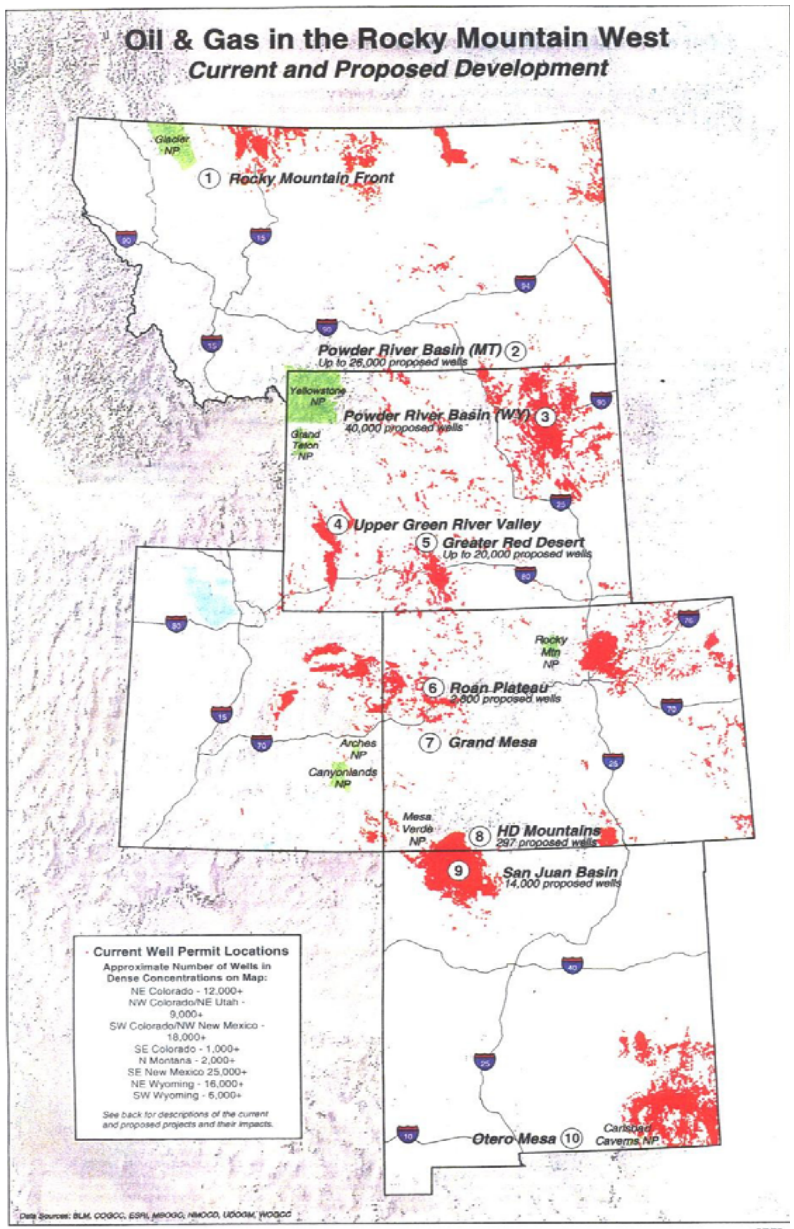


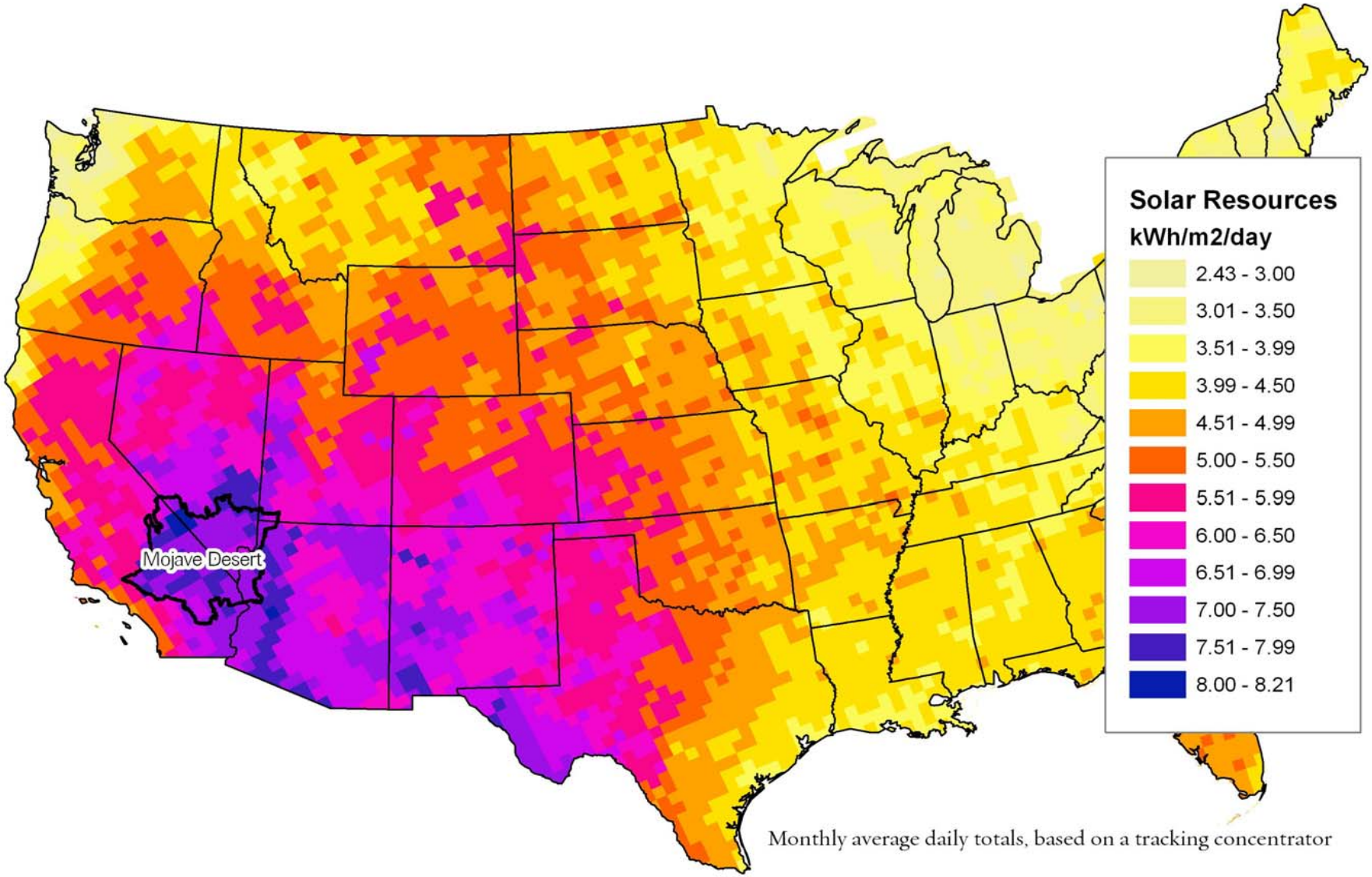
* Source: EIA Annual Energy Review 2007

Energy Security/Energy Independence

At a time of growing concern over the rising costs and long-term environmental impacts of the use of fossil fuels and nuclear energy, wind energy has become an increasingly important sector of the electrical power industry, largely because it has been promoted as being emission-free

Scale of O & G Threat





Monthly average daily totals, based on a tracking concentrator

Wind's Footprint

Wind Farm Area Calculator
This calculator estimates land-area requirements for wind power systems. The results indicate a "footprint" of land that has to be taken out of production to provide space for turbine towers, roads, and support structures.

The "footprint," which is typically between 0.25 and 0.50 acres per turbine, does not include the 5-10 turbine diameters of spacing required between wind turbines. Because of this spacing, the area included within the perimeter of the wind farm will be larger. However, it is important to note that the land between the turbines - minus the "footprint" area - is still usable for its original purpose.

The estimated land area required is: **0.76 acres**.
This calculation assumes **1,000 kW** and **2 turbines** each requiring an area of **0.38 acres**.

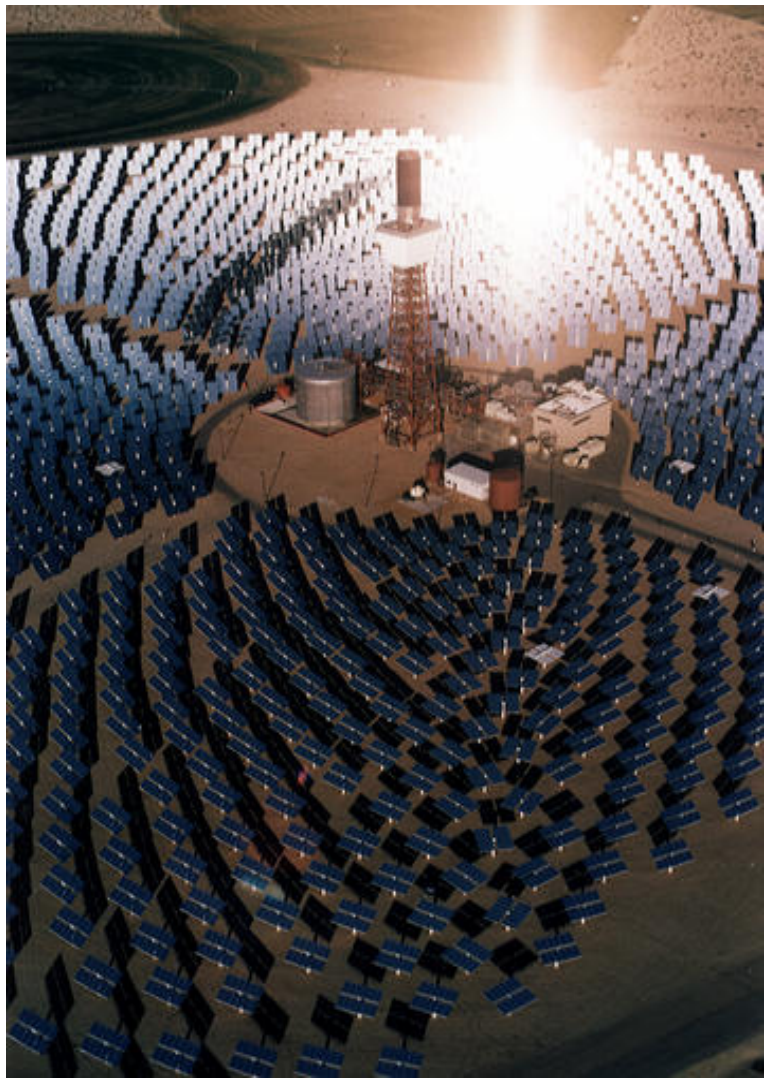
Solar's Footprint

PV (photovoltaic systems) Area Calculator
This calculator uses assumptions about land area requirements for photovoltaic systems to estimates total land area requirements for a system of a given size after subtracting the portion of PV that may be placed on rooftops of buildings.

Result: **1,000 kW** of photovoltaics is estimated to require **6.4 acres**.
This calculation assumes a generating capacity of **1,000 kW**, where each kW requires an average of **0.004 acres per kW**, and that the first **20%** of this capacity is placed on rooftops, and further that the remaining capacity is placed on land where the photovoltaic panels can cover **50%** of the land area.

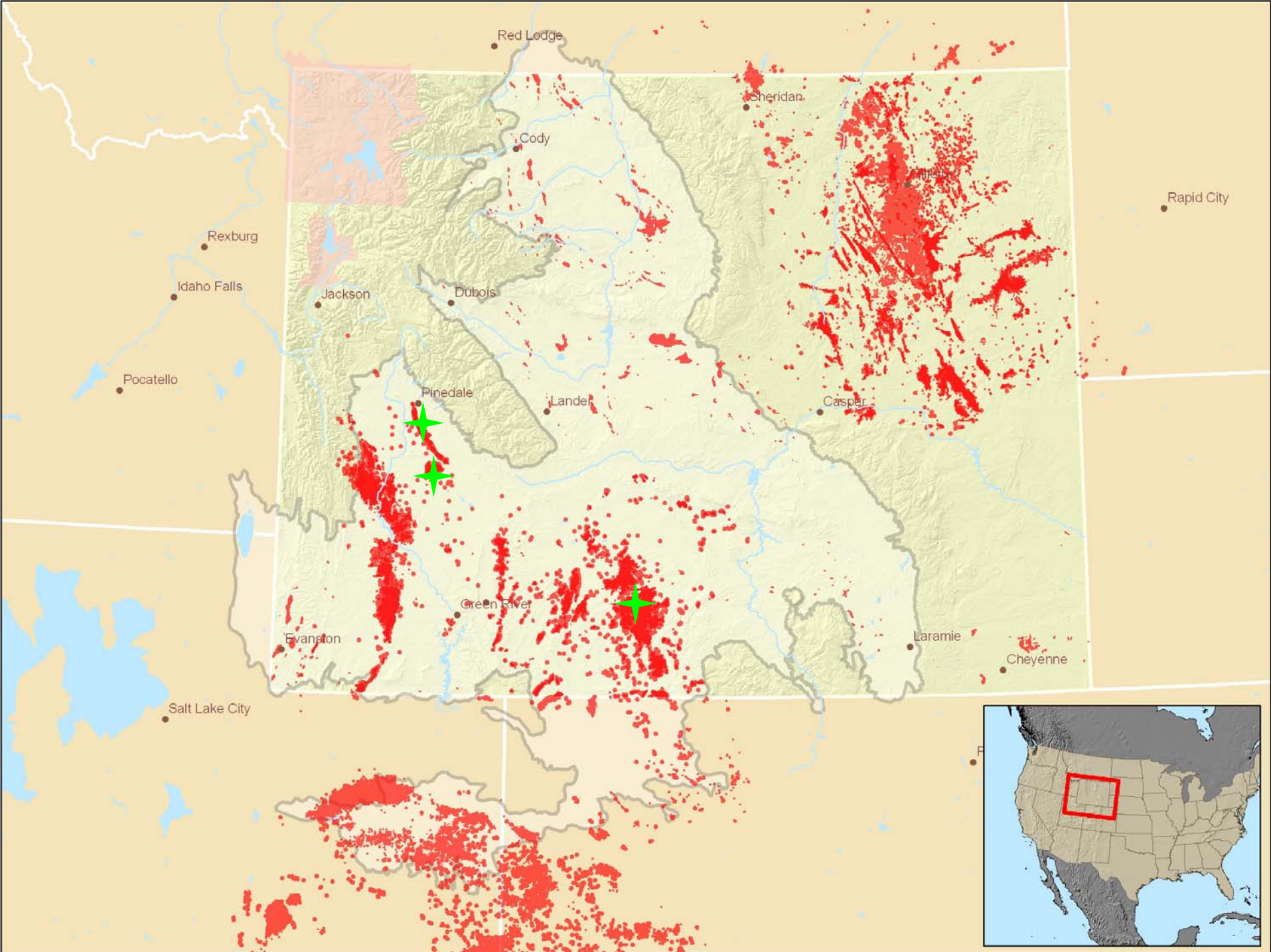
U. S. National goals

– Wind: 20% of total provided energy by 2030
– Solar: 10% of total provided energy by 2030



Mitigation, as defined by the Council on Environmental Quality, may include one or more of the following:

1. Avoid …
2. Minimize…
3. Rectify (repair or restore)…
4. Offset the impact by replacing or providing substitute resources or environments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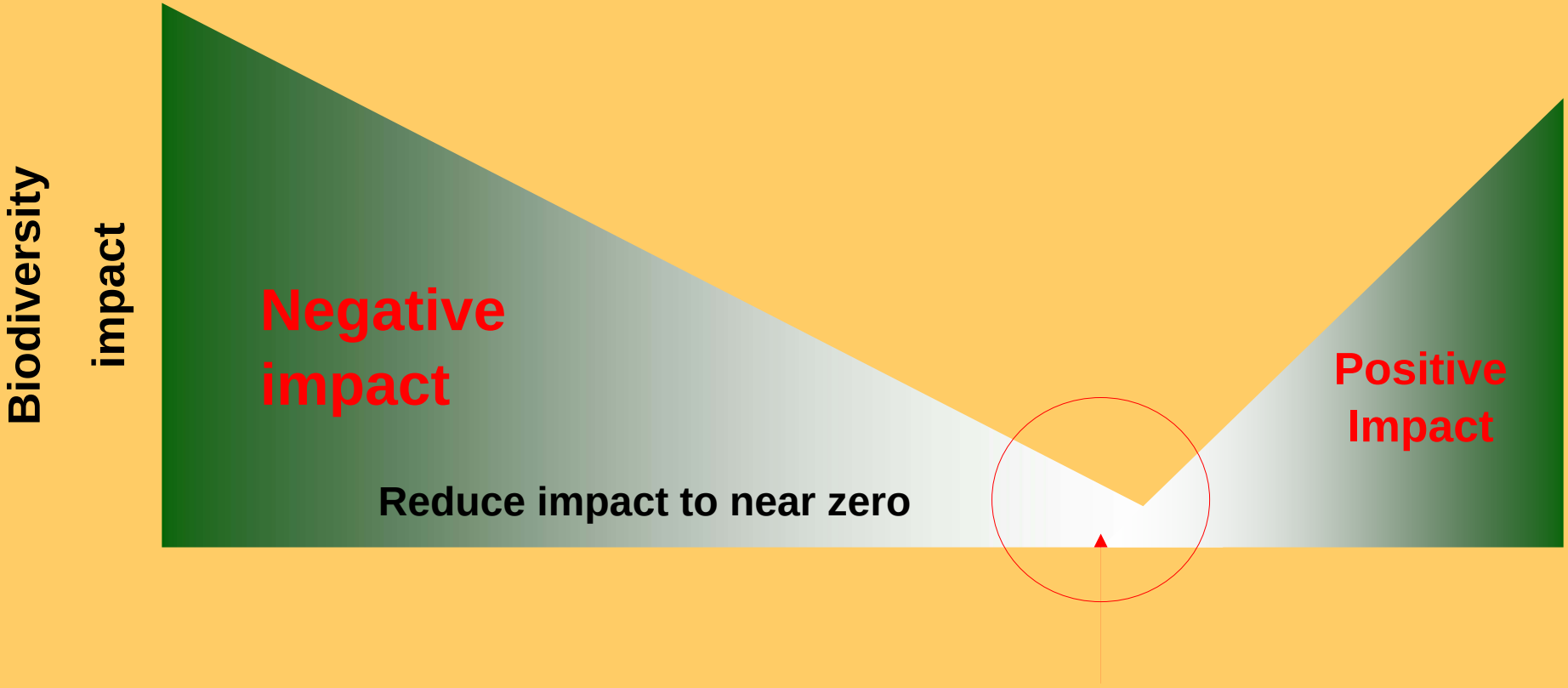
Sheridan
Cody
Rapid City
Rexburg
Idaho Falls
Jackson
Dubois
Pocatello
Pinedale
Lander
Casper
Green River
Evanston
Laramie
Cheyenne
Salt Lake City

Energy by Design Impact Mitigation

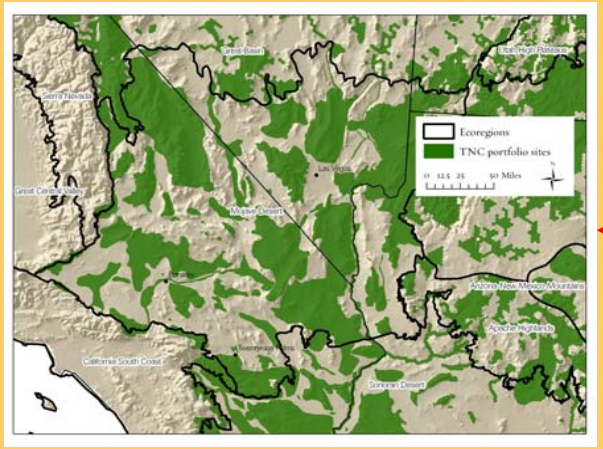


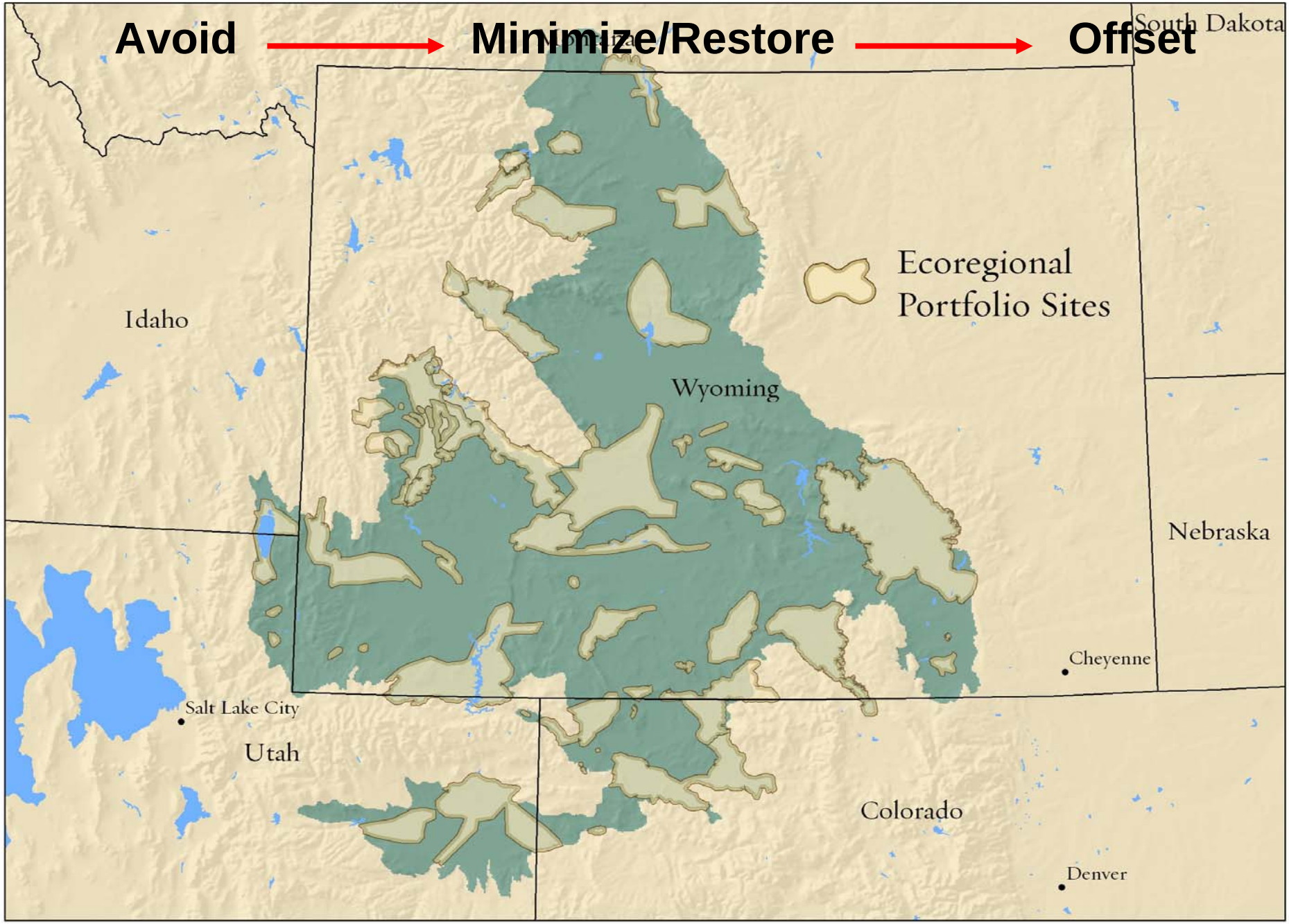
Avoid → Minimize/Restore → Offset

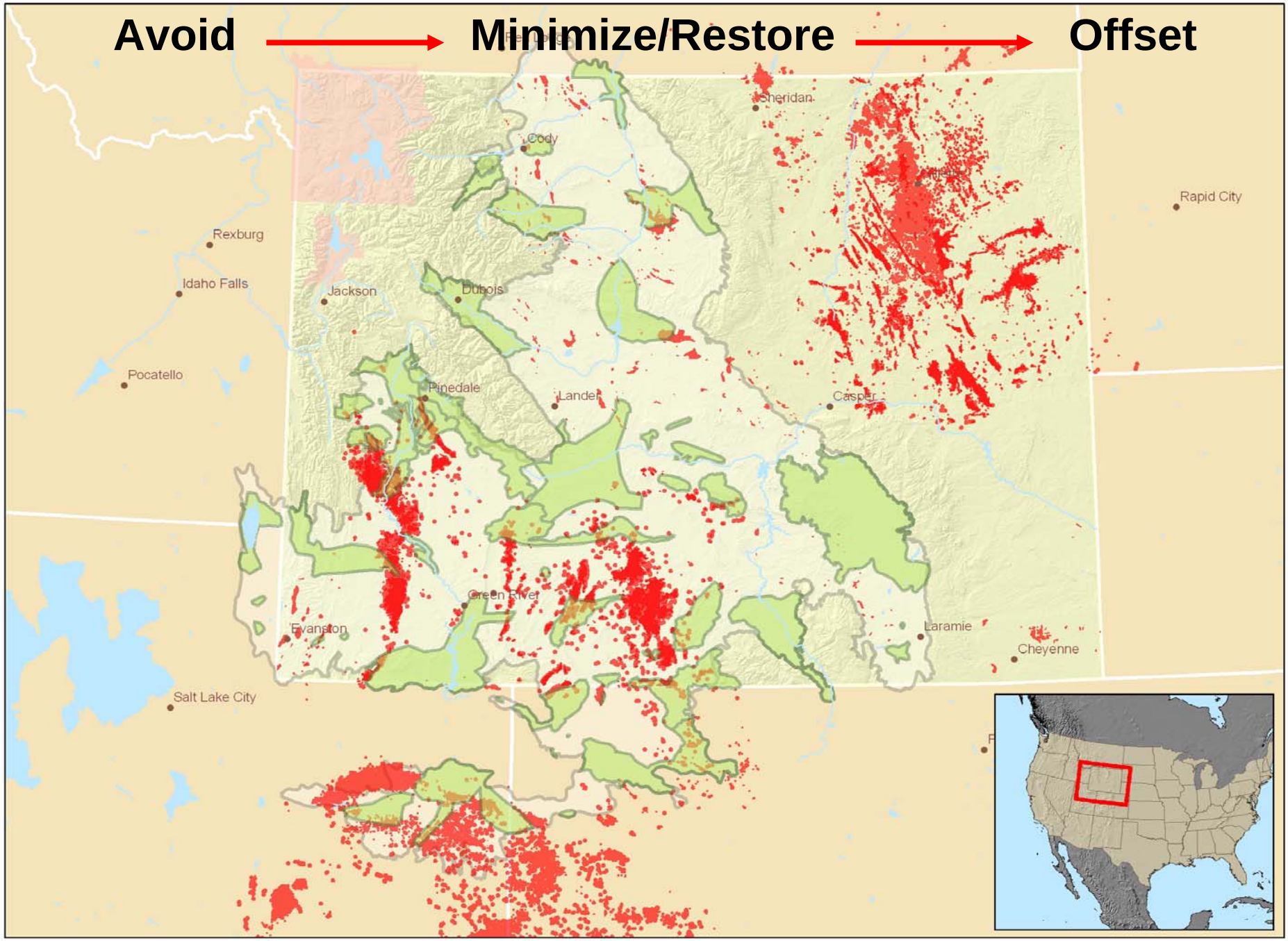
The mitigation hierarchy

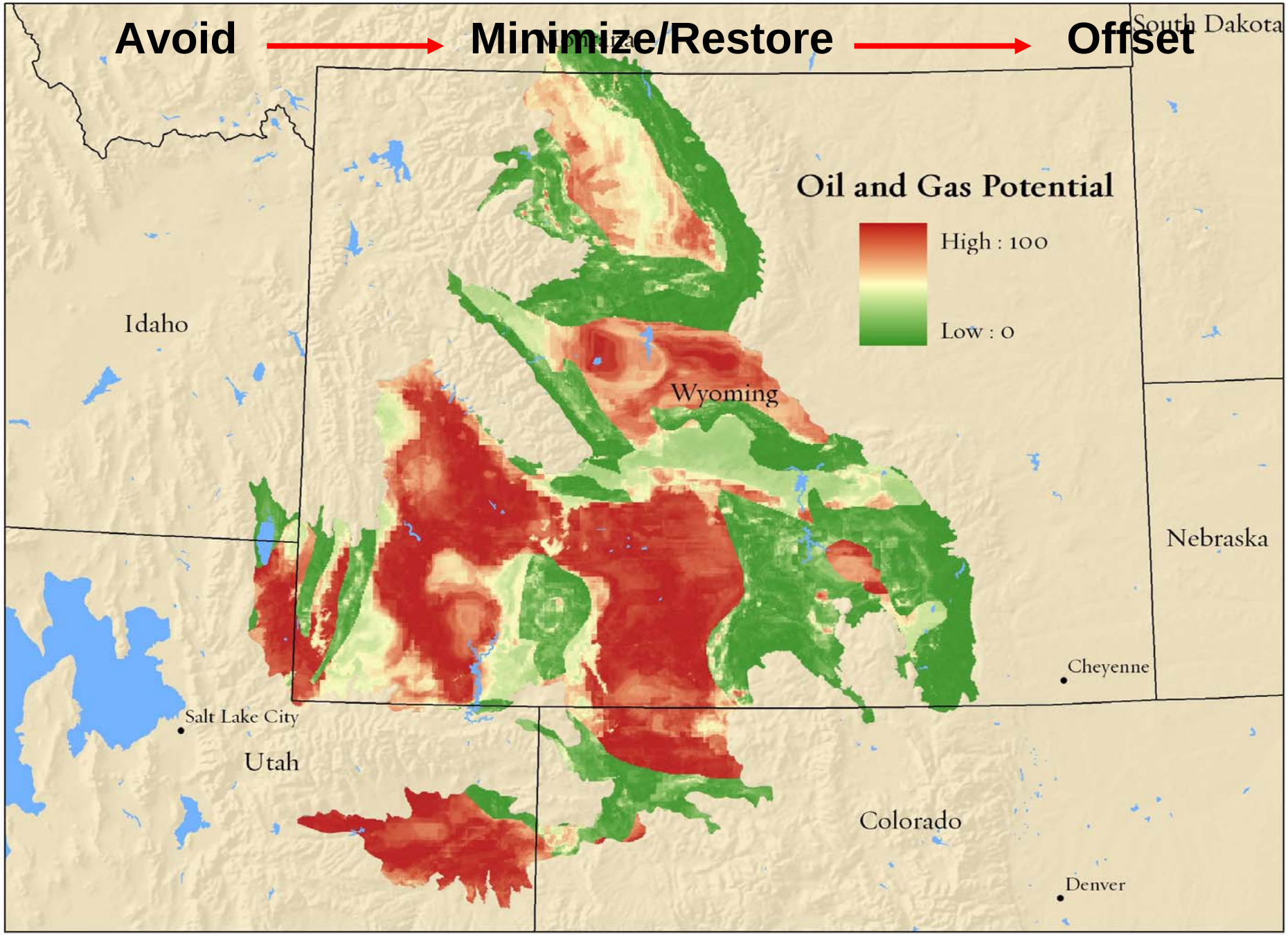
TNC SCIENCE

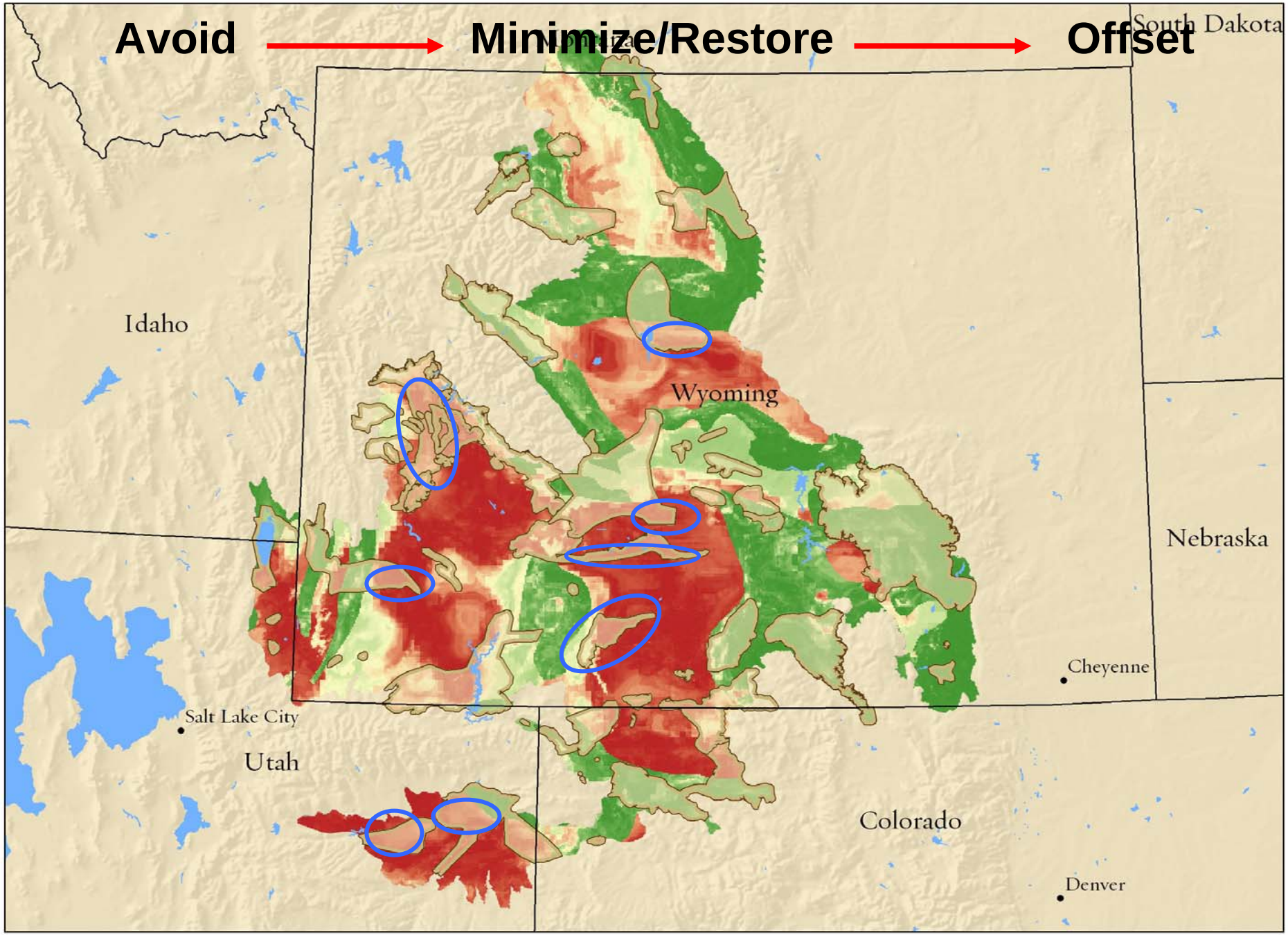
Ecoregional Planning




Avoid
Minimize/Restore
Offset
Montana
South Dakota
Idaho
Ecoregional
Portfolio Sites
Wyoming
Nebraska
Cheyenne
Salt Lake City
Utah
Colorado
Denver


Avoid
Minimize/Restore
Offset
Sheridan
Cody
Rapid City
Rexburg
Idaho Falls
Jackson
Dubois
Pocatello
Pinedale
Lander
Casper
Green River
Evanston
Laramie
Cheyenne
Salt Lake City


Avoid
Minimize/Restore
Offset
Montana
South Dakota
Oil and Gas Potential
High : 100
Low : 0
Idaho
Wyoming
Nebraska
Cheyenne
Salt Lake City
Utah
Colorado
Denver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Minimize/Restore
Offset
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Idaho
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Nebraska
Cheyenne
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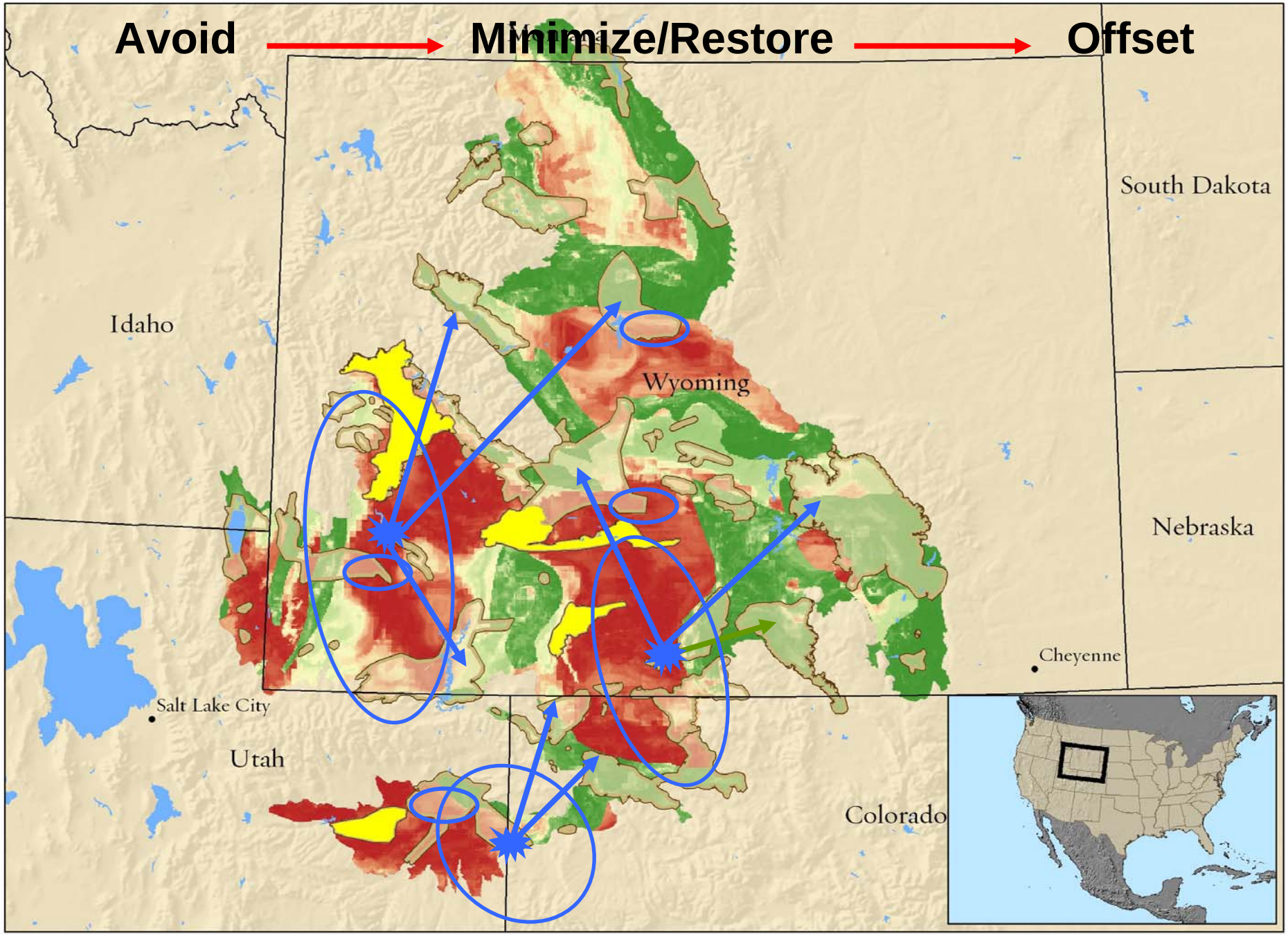
Utah
Colorado
Denver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South Dakota
Nebraska
Cheyenne
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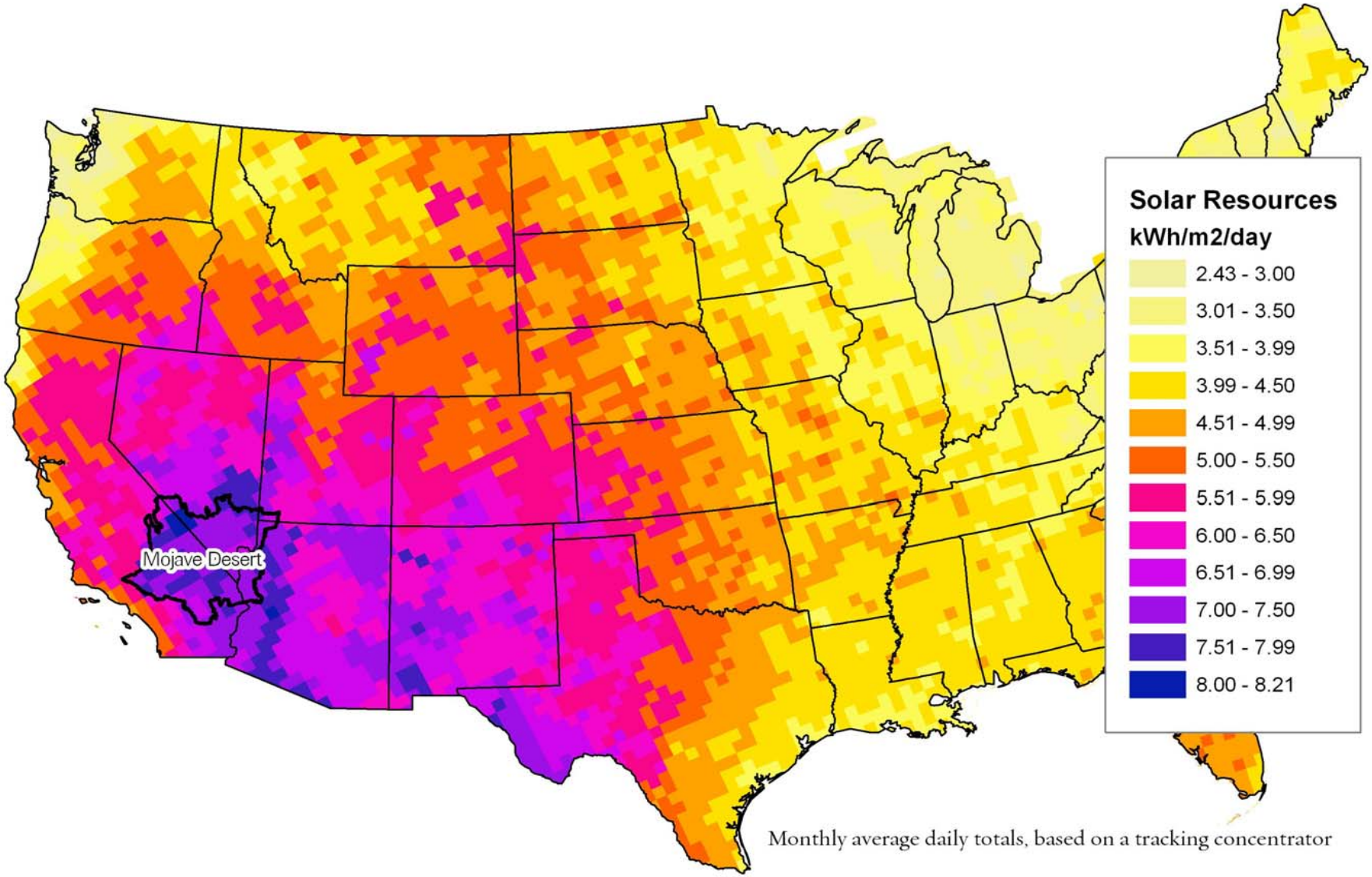
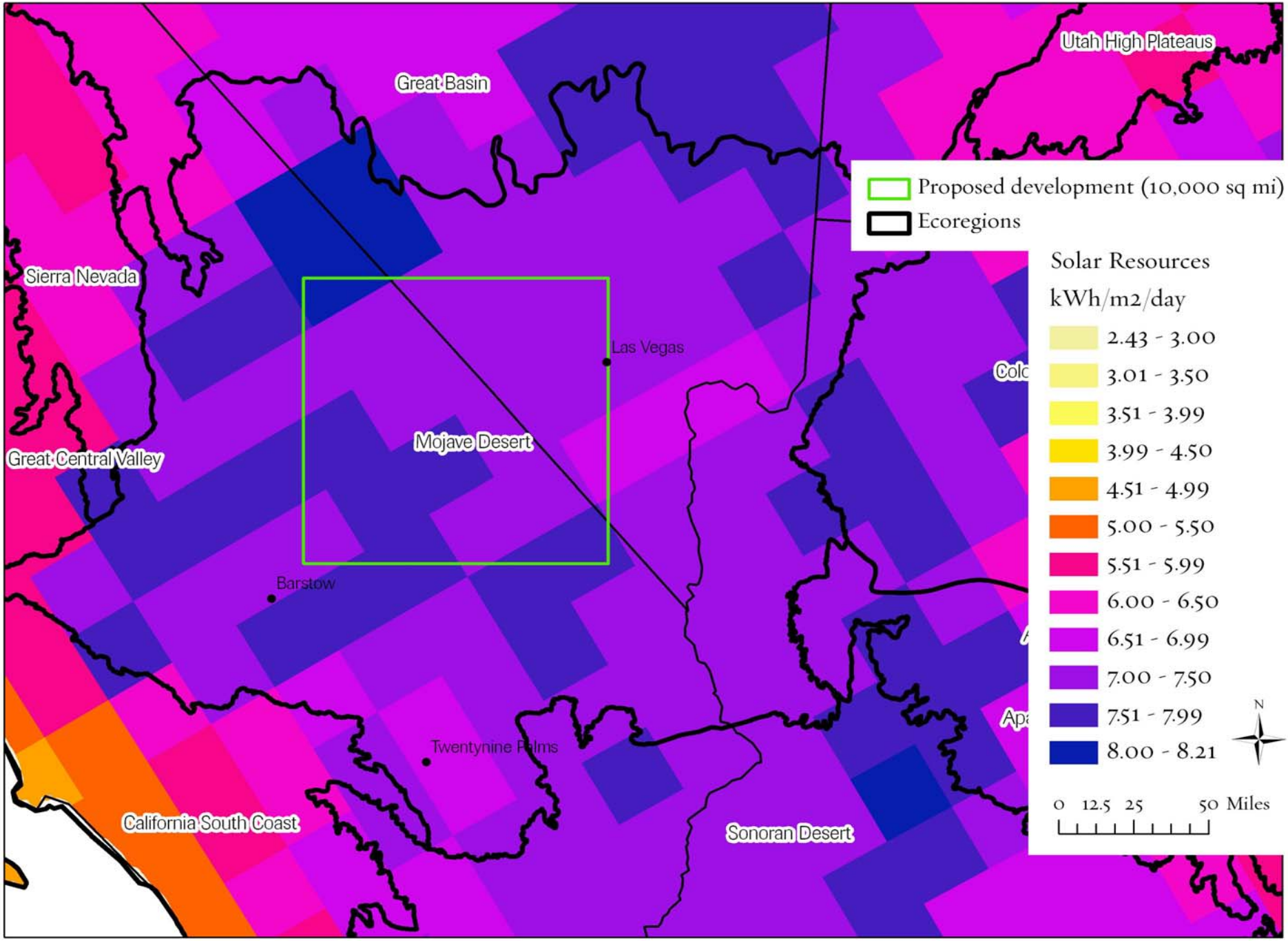
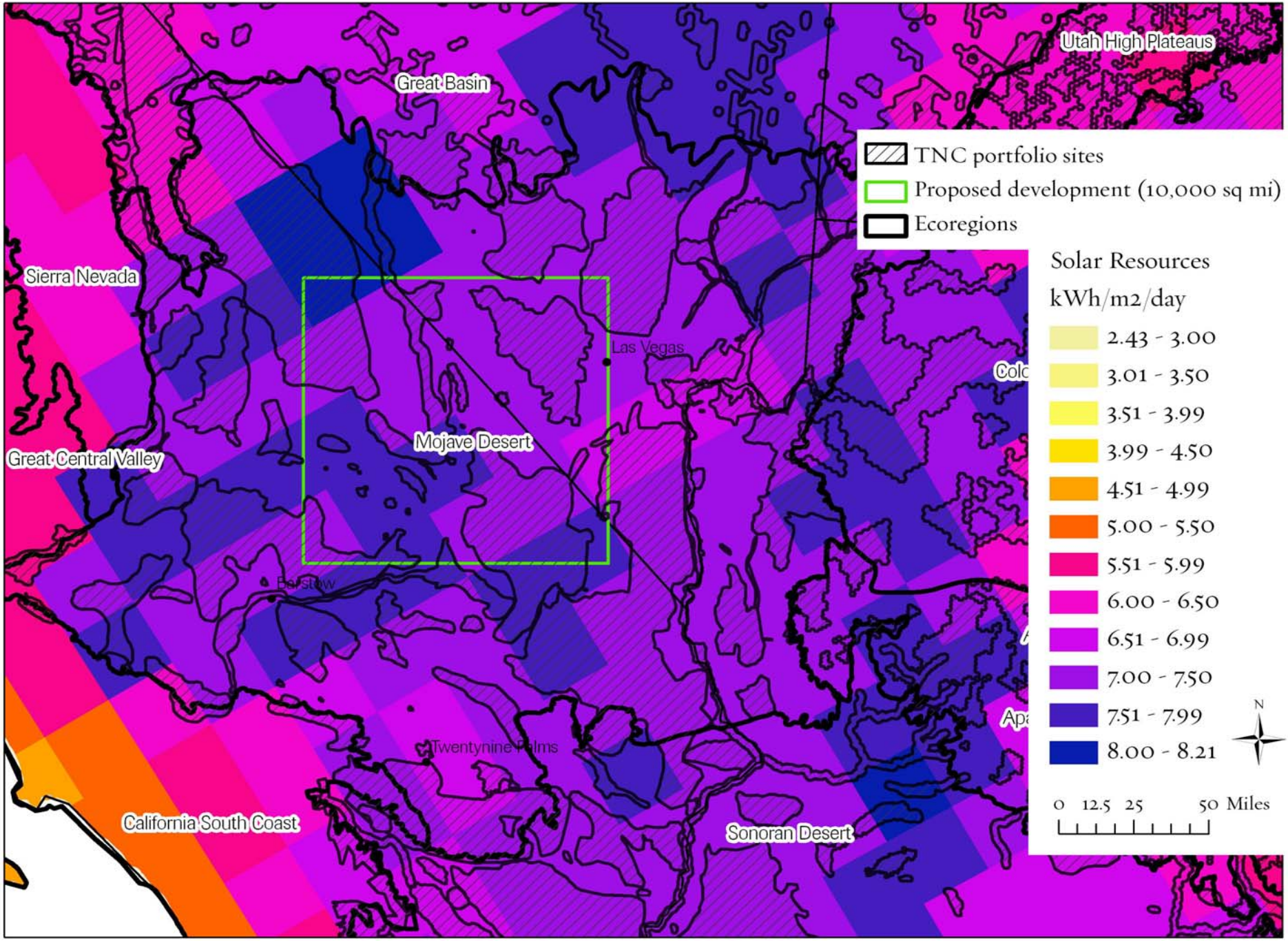
Colorado



Monthly average daily totals, based on a tracking concentrator

Great Basin
Utah High Plateaus
Sierra Nevada
Ecoregions
TNC portfolio sites
0 12.5 25 50 Miles
N
Las Vegas
Great Central Valley
Mojave Desert
Barstow
Arizona-New Mexico Mountains
Apache Highlands
Twentynine Palms
California South Coast
Sonoran Desert


Utah High Plateaus
Great Basin
Proposed development (10,000 sq mi)
Ecoregions
Solar Resources
kWh/m2/day
2.43 - 3.00
3.01 - 3.50
3.51 - 3.99
3.99 - 4.50
4.51 - 4.99
5.00 - 5.50
5.51 - 5.99
6.00 - 6.50
6.51 - 6.99
7.00 - 7.50
7.51 - 7.99
8.00 - 8.21
N
0 12.5 25 50 Miles
Sierra Nevada
Las Vegas
Mojave Desert
Great Central Valley
Barstow
Twentynine Palms
California South Coast
Sonoran Desert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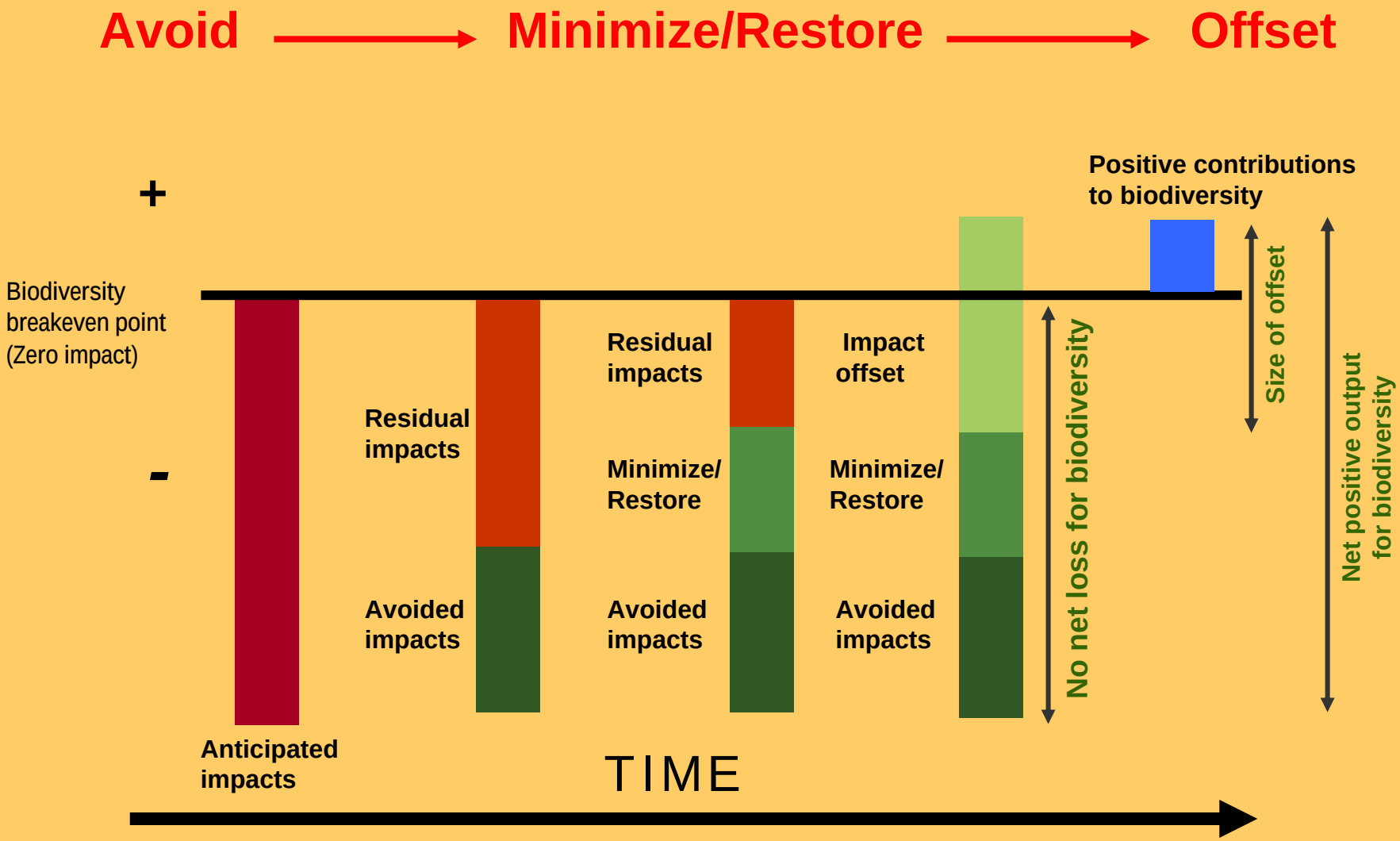

From Kiesecker et al. In Prep

Kiesecker, J.M, H. Copeland, A. Pocewicz, N. Nibbelink, B. McKenney J. Dahlke, M. Holloran and D. Stroud A Framework for Implementing Biodiversity Offsets: Selecting Sites and Determining Scale. (Submitted to *BioScience*)

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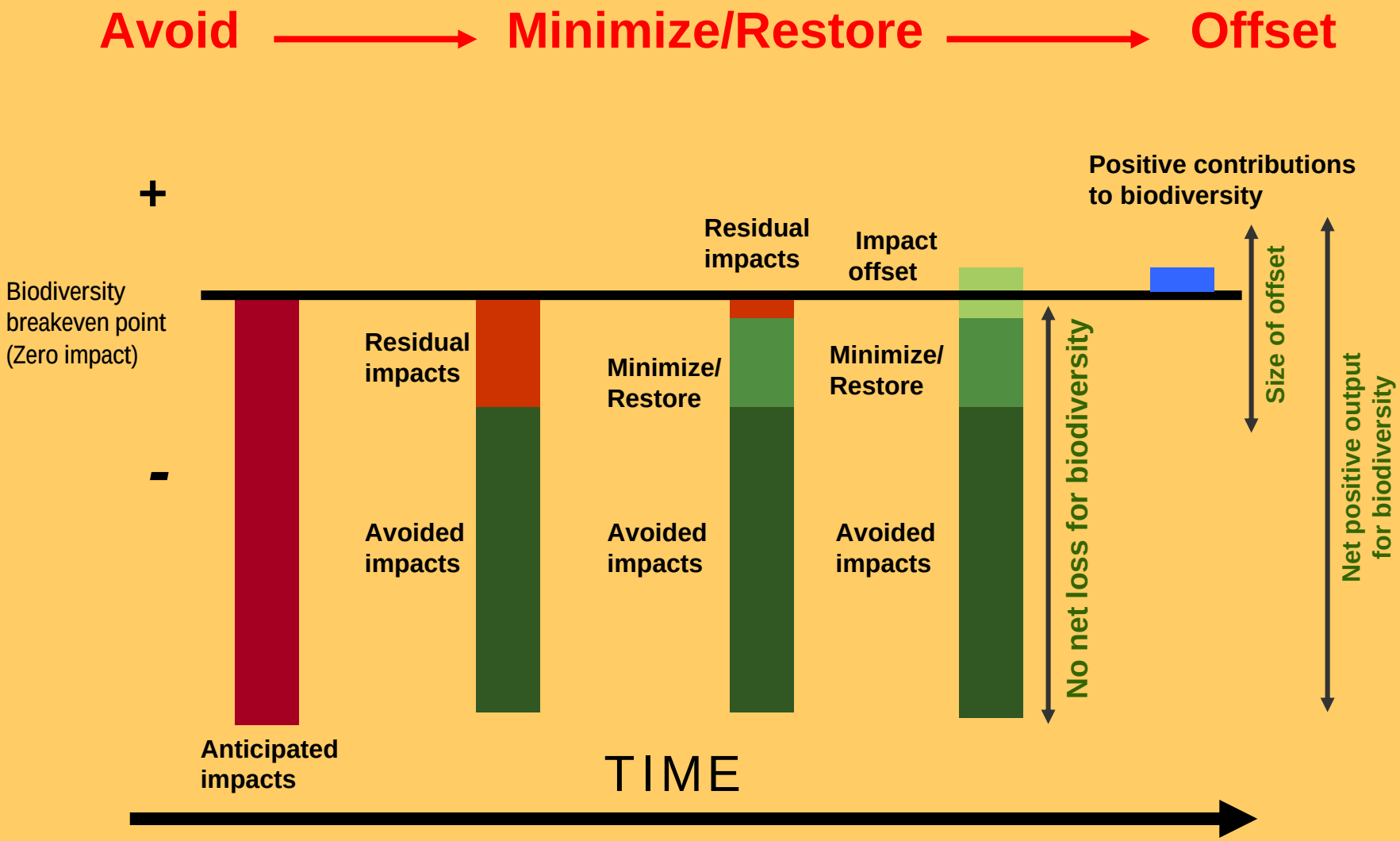

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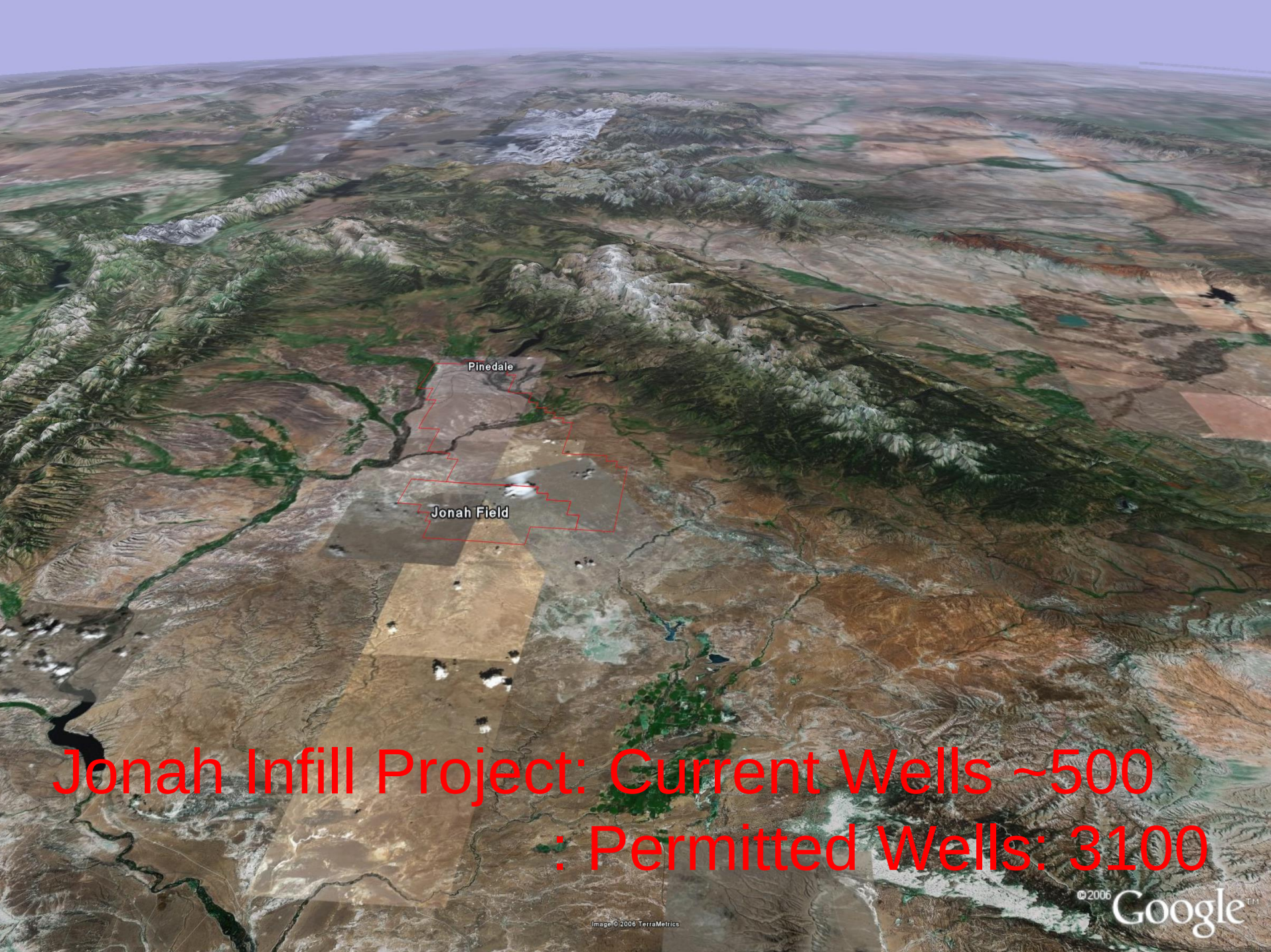

Pinedale
Jonah Field
Jonah Infill Project: Current Wells ~500
: Permitted Wells: 3100
Image © 2006 TerraMetrics
© 2006 Google

A window of opportunity…

- Off-site mitigation has been agreed to by the BLM, State of Wyoming and operators (Encana, BP) on the Jonah Field

- No standard criteria or methodology has been identified to inform project selection

- BP, a long standing partner with TNC and co-signer of the Energy and Biodiversity Initiative (EBI), has invited TNC to design a methodology

- TNC has both methodology and technical capacity for large landscape analysis of biodiversity. This is one of the key ways for TNC to engage

Off-Site Mitigation Design Project Process

Assemble Team of Experts

↓

Compile Key Species List for Jonah

↓

Gather Spatial Data & Develop Species Models

↓

Set Species & Vegetation Goals

↓

Run Marxan Model

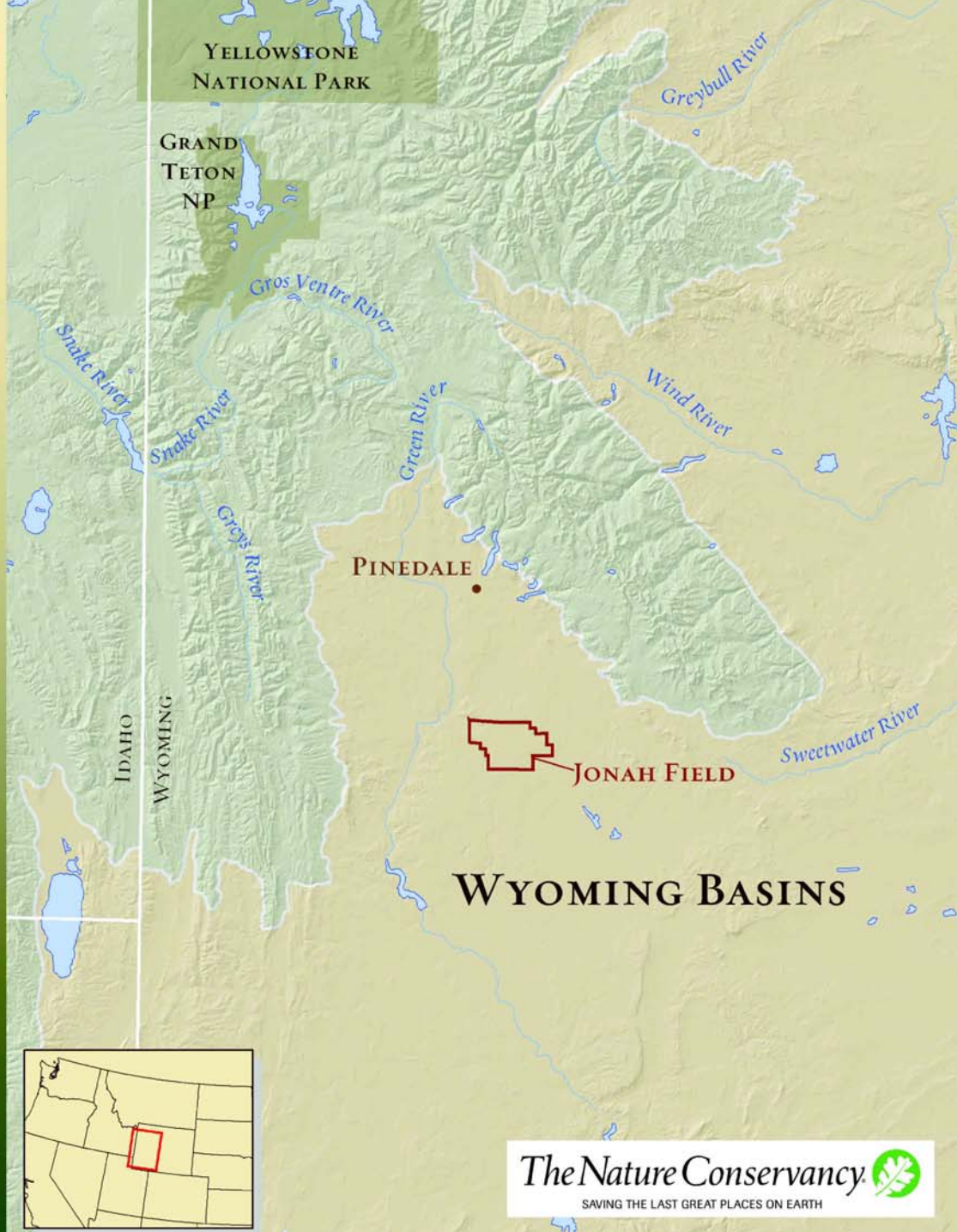
↓

Validate Model Results

↓

Report Results & Track Progress

**Each step includes expert review*



The Nature Conservancy
SAVING THE LAST GREAT PLACES ON EARTH

Jonah Mitigation Goals

Target Name	Goal (Ha)	Goal (Acres)	Goal (Number)	Minimum Viable Size
Burrowing owl	13,690	33,828		220 ha
Cedar Rim thistle	3,433	8,483		n/a
Mountain plover	1,390	3,435		1000 ha
Pronghorn migration	7,738	19,121		n/a
Pygmy rabbit	20,804	51,407		1100 ha
Sage grouse (occupied leks)			6	n/a
Sage grouse (winter/nesting/early brood-rearing habitat)	20,955	51,780		700 ha
Sage sparrow	8,813	21,777		100 ha
White-tailed prairie dog	1,705	4,213		2024 ha
Wyoming big sagebrush	22,573	55,778		6880 ha

Jonah Field
©2006 Google™

Brewers Sparrow
Sage sparrow
NELSON PHACELIA
Prairie Dog Town
Sage Grouse Lek
Prairie Dog Town
SICKLE SALTBUSH
Sage Grouse Lek
Sage Grouse Lek
Burrowing owl
Sage Grouse Lek
Sage Grouse Lek
Sage Grouse Lek
Pygmy rabbit
Jonah Field
Burrowing owl
Prairie Dog Town
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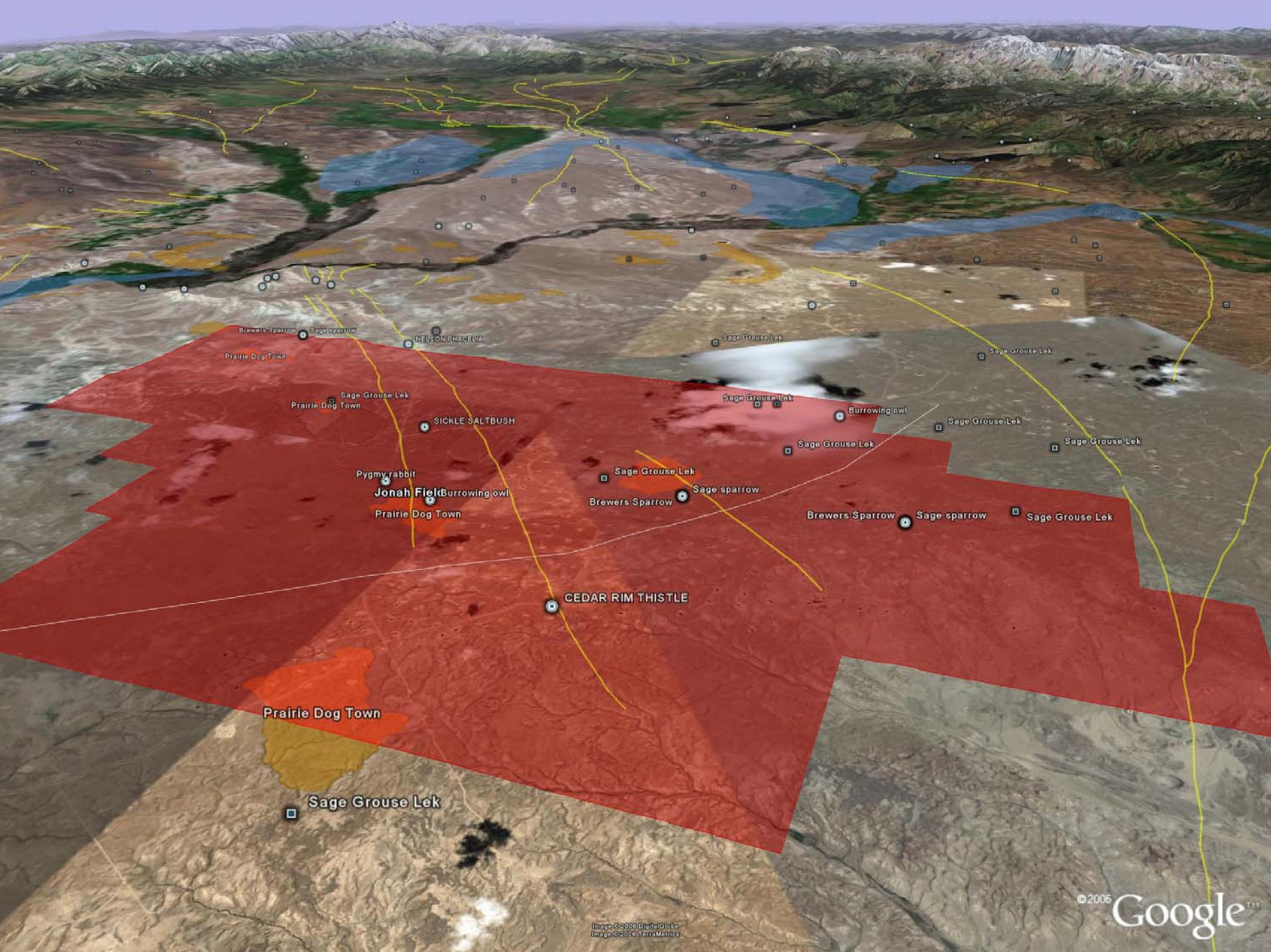
Brewers Sparrow
Sage sparrow
Brewers Sparrow
Sage sparrow
Sage Grouse Lek
CEDAR RIM THISTLE
Prairie Dog Town
Sage Grouse Lek
©2006 Google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Sage sparrow
NELSON PHACELIA
Prairie Dog Town
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Sage Grouse Lek
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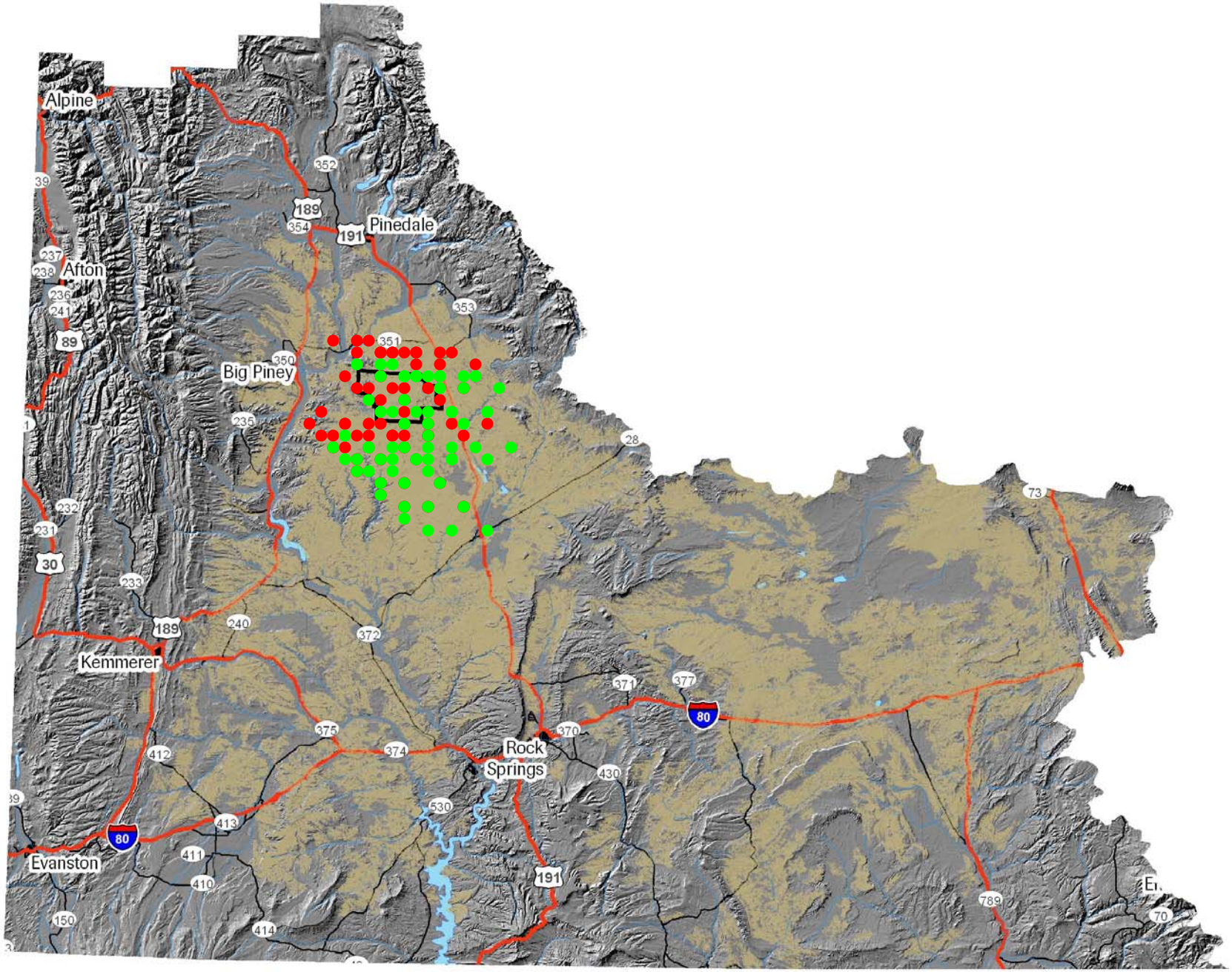
Alpine
Afton
Pinedale
Big Piney
Kemmerer
Rock Springs
Evanston
189
191
89
30
80
352
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351
350
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150
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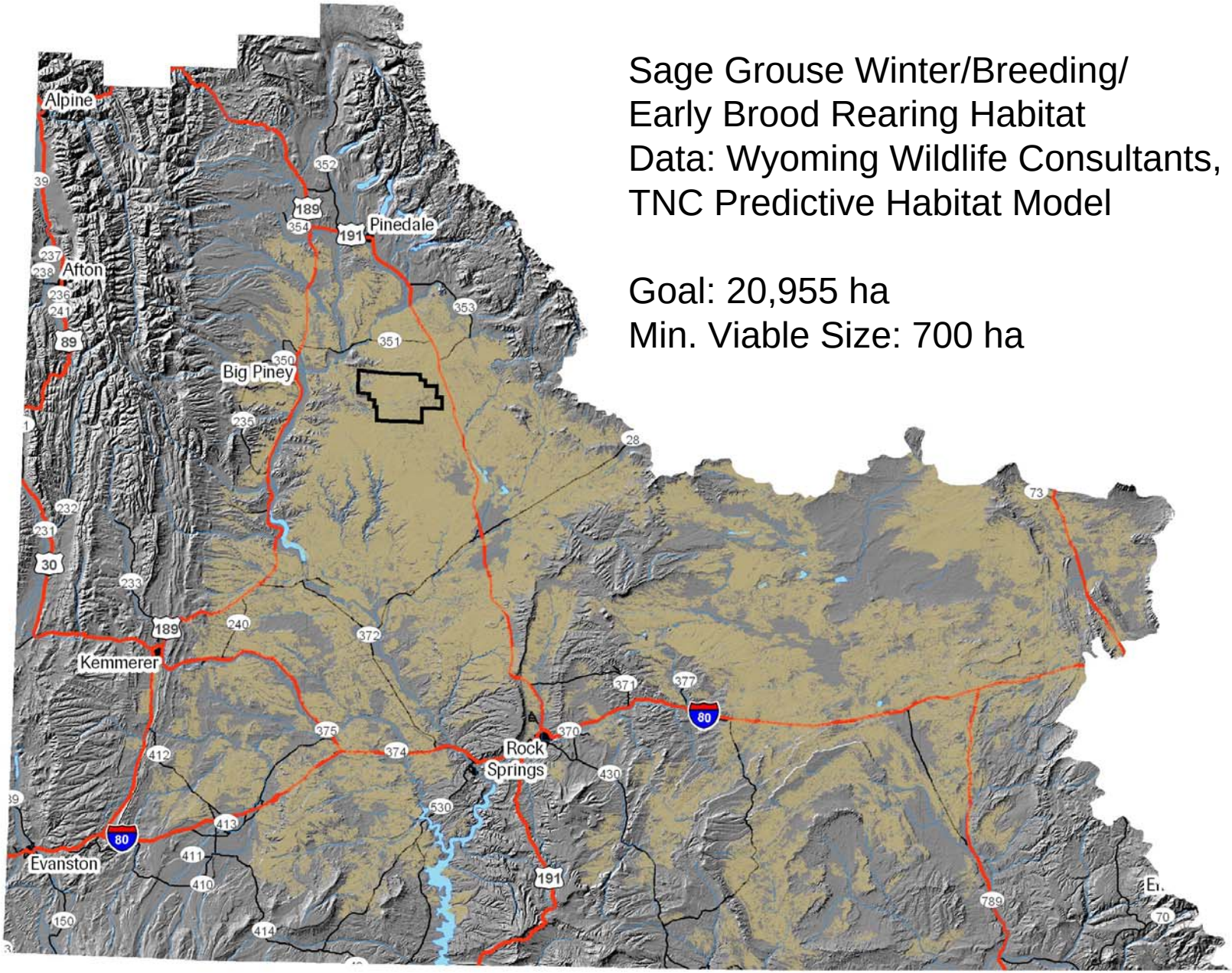
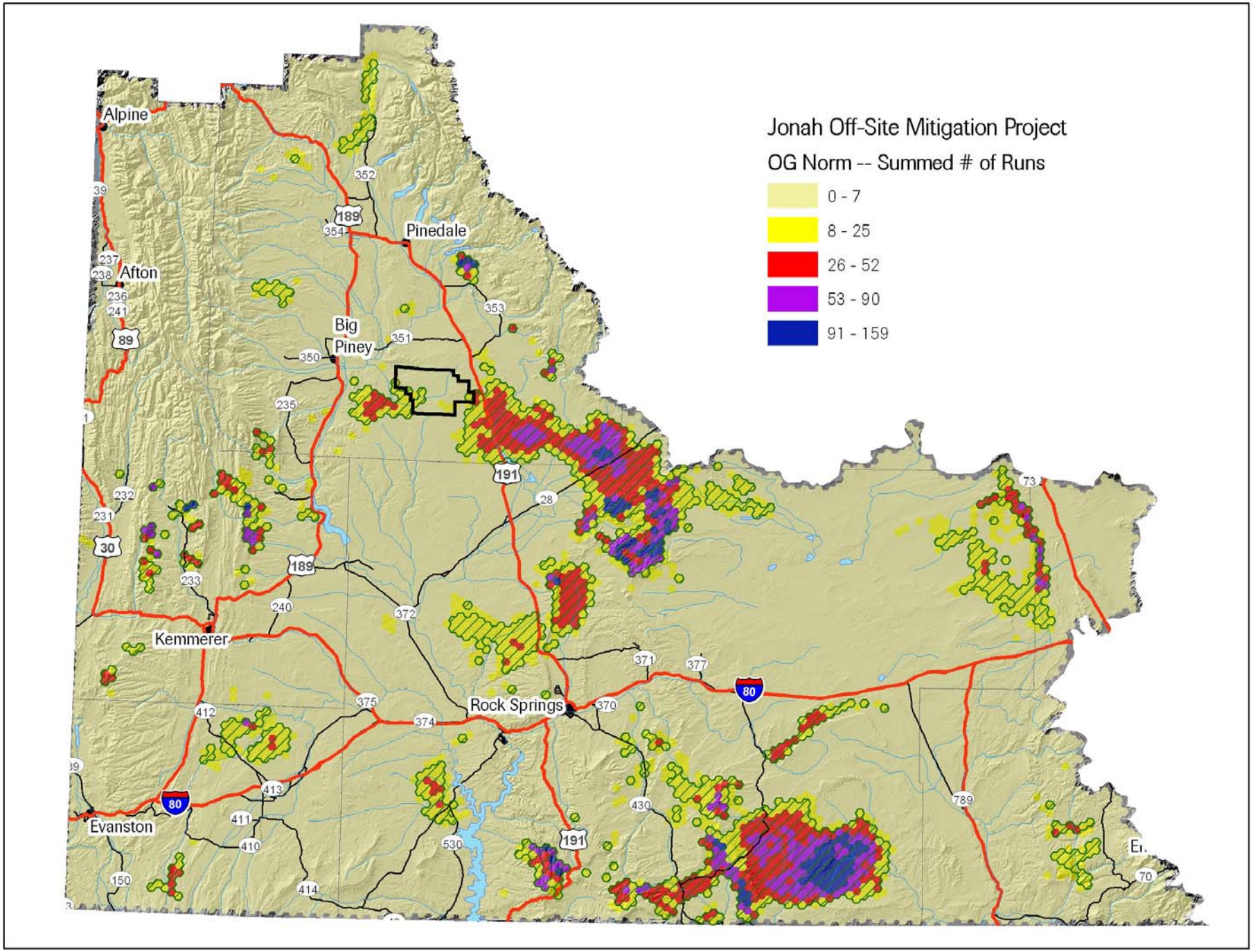


Sage Grouse Winter/Breeding/
Early Brood Rearing Habitat
Data: Wyoming Wildlife Consultants, LLC
TNC Predictive Habitat Model

Goal: 20,955 ha
Min. Viable Size: 700 ha


Jonah Off-Site Mitigation Project
OG Norm -- Summed # of Runs
0 - 7
8 - 25
26 - 52
53 - 90
91 - 159
Alpine
Afton
Pinedale
Big Piney
Kemmerer
Rock Springs
Evanston
89
189
191
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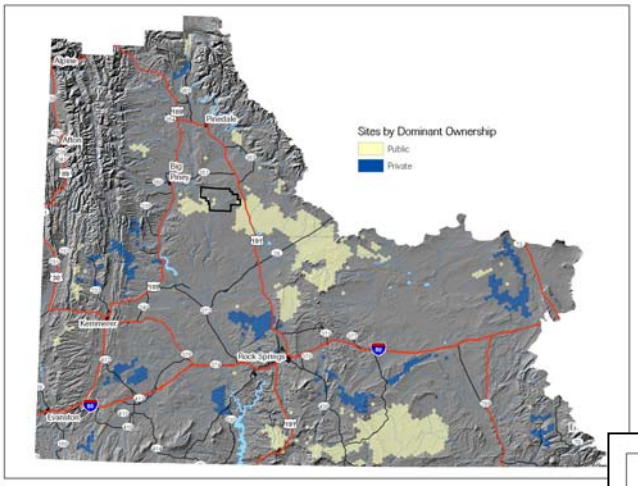
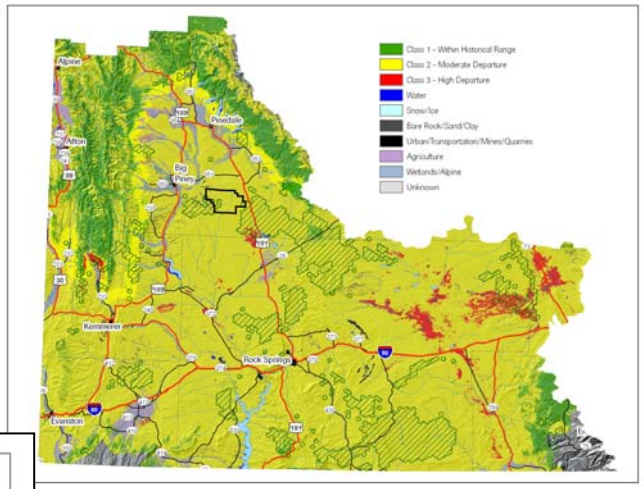
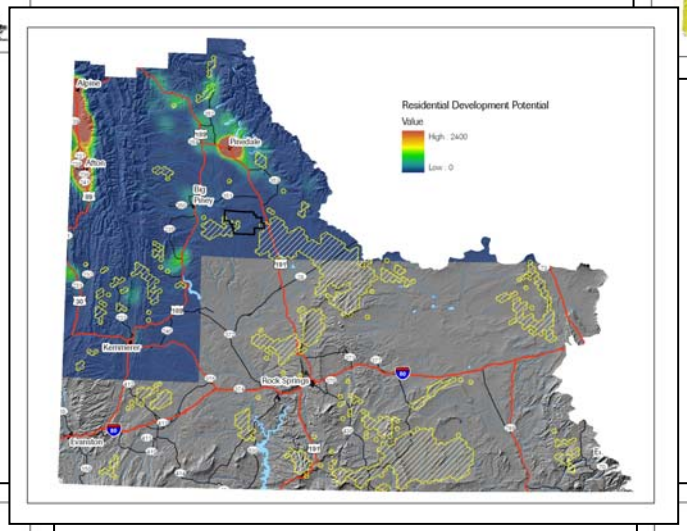


Dominant Land Ownership

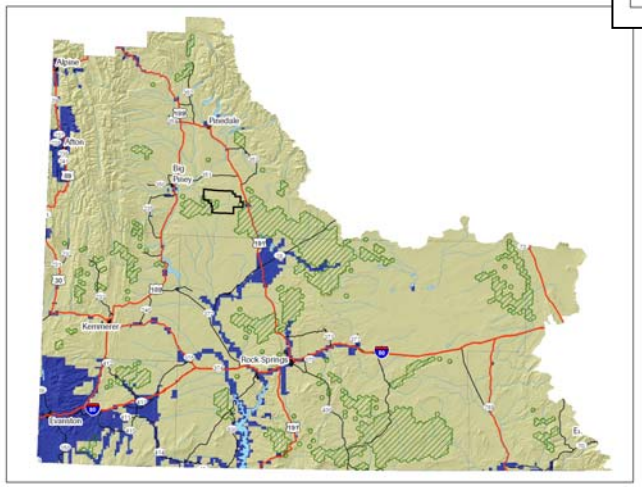


Fire Condition Class

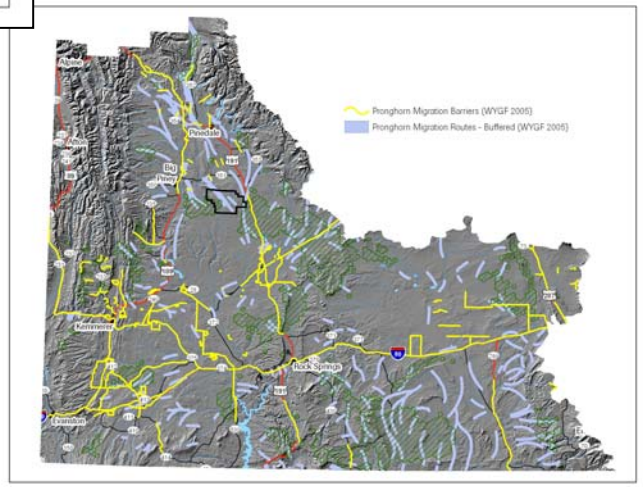


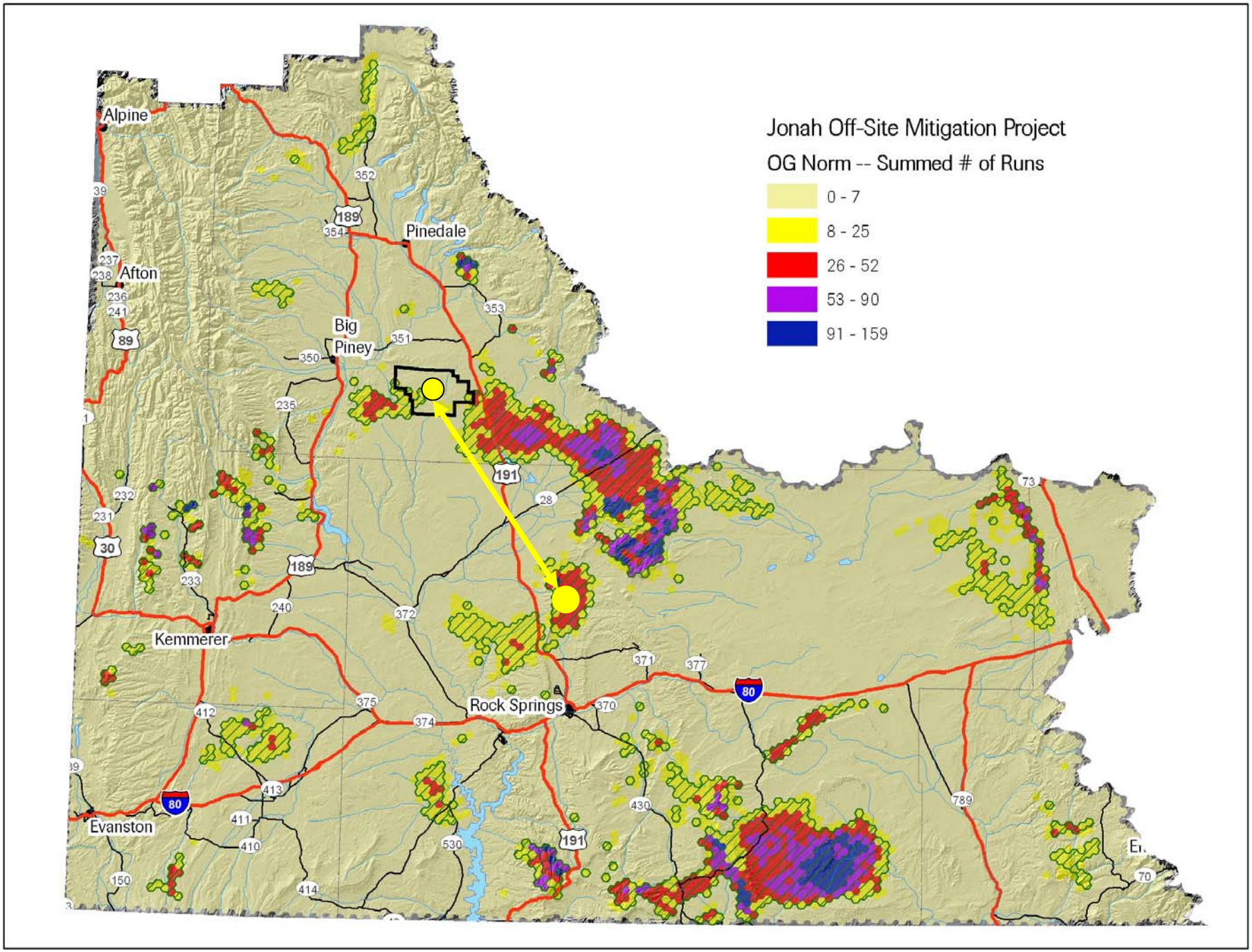
Residential Development

Invasive Weeds



Barriers to migration

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Jonah Mitigation Project Review

Project	Sage Grouse Leks	Cedar-Rim Thistle (%)	Pronghorn Migration (%)	Burrowing Owl (%)	Prairie Dog (%)	Mountain Plover (%)	Pygmy Rabbit (%)	Sage Grouse (%)	Sagebrush (%)	Sage Sparrow (%)	Summed % towards Goal
Cottonwood Ranch	100%	0%	43%	14%	111 %	24%	123%	32%	32%	11%	**489%**
Elk-Mountain Red Canyon Burn	0%	1%	0%	0%	0%	1%	73%	1%	7%	2%	**84%**
MJ Ranch	100%	0%	68%	60%	480 %	0%	156%	70%	50%	0%	**984%**
Murdock	17%	0%	1%	0%	3%	0%	5%	1%	1%	0%	**27%**
Onion Springs Res. Reclamation Project	0%	0%	1%	1%	6%	0%	3%	1%	1%	0%	**12%**
Tibbals Reservoir	0%	0%	2%	1%	9%	0%	2%	1%	1%	0%	**17%**

The business case for biodiversity offsets

- Access to land and resources: Significant coincidence between development conservation interests.

- Maintaining license to operate: Address concern for biodiversity loss:
  - Increased "regulatory goodwill": Good relationships with regulators can lead to faster permitting. "Preferred partner" status.
  - Social license to operate: Better relationships with local communities, government regulators, environmental groups, employees.

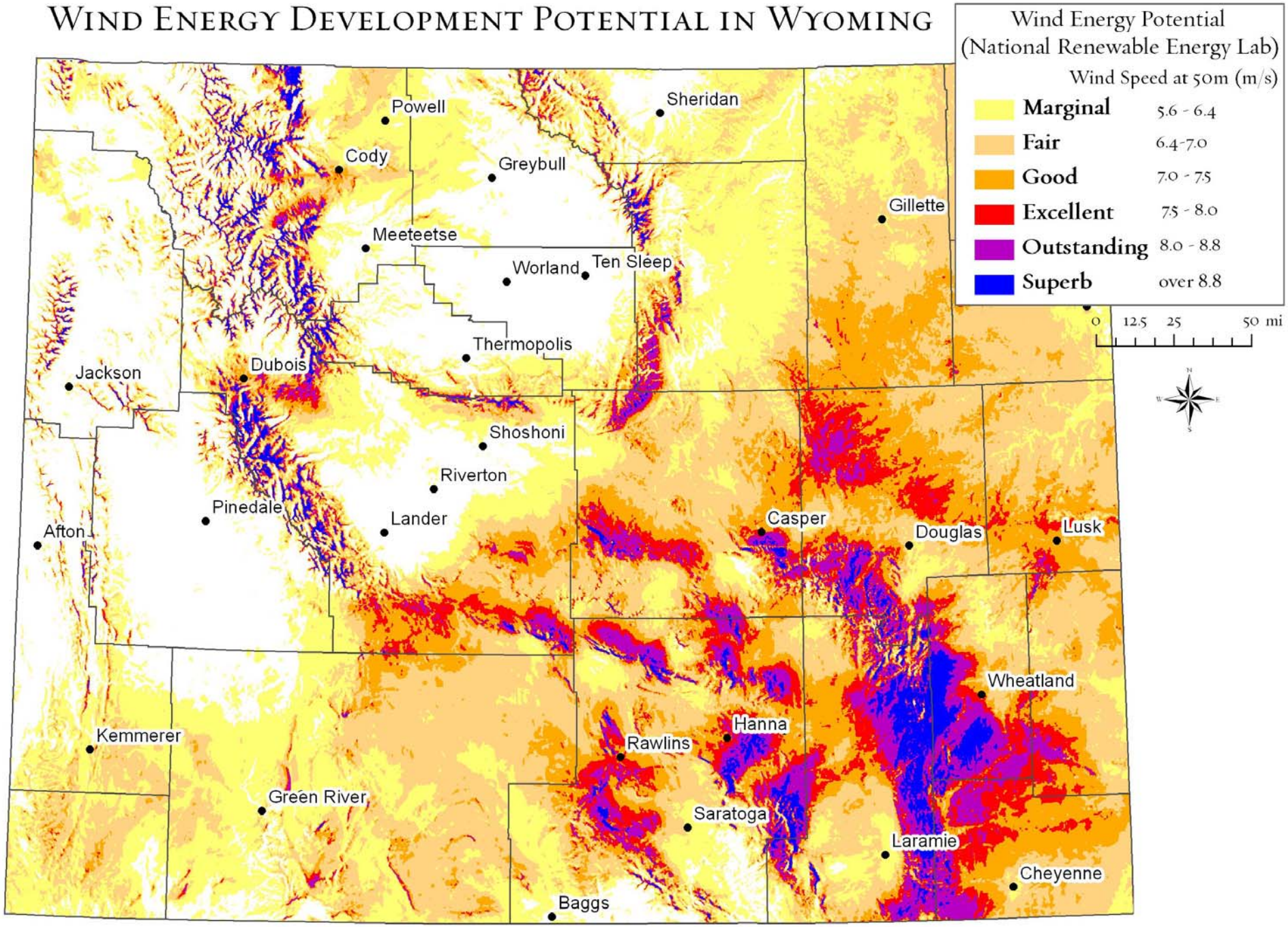
- Flexibility: location/scale of rehabilitation.

- Efficiency: often more cost-effective than on-site rehabilitation.

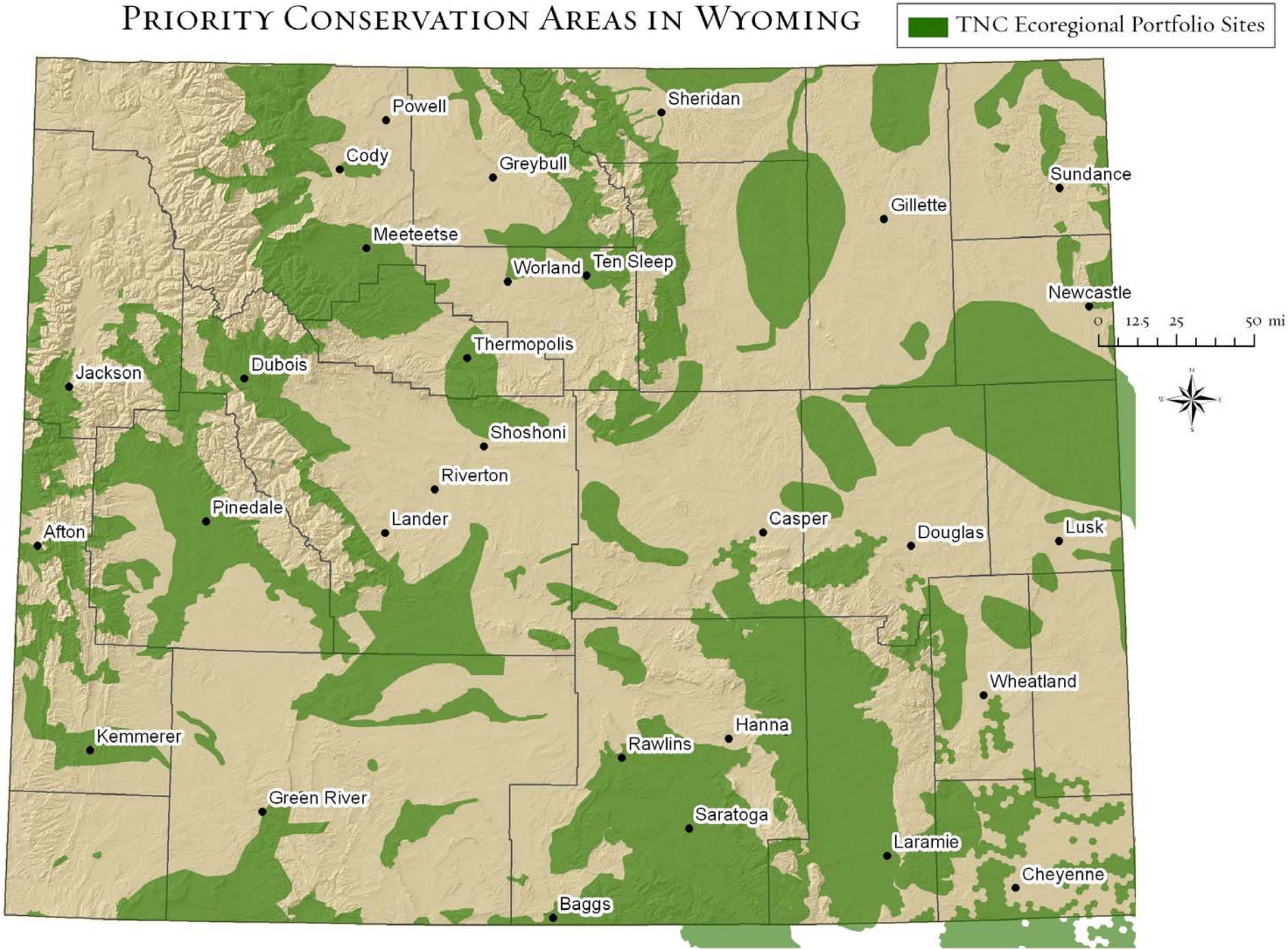
- Reputation benefits e.g. easier access to capital and labour

- Influence emerging regulation and policy. "First mover" advantage.

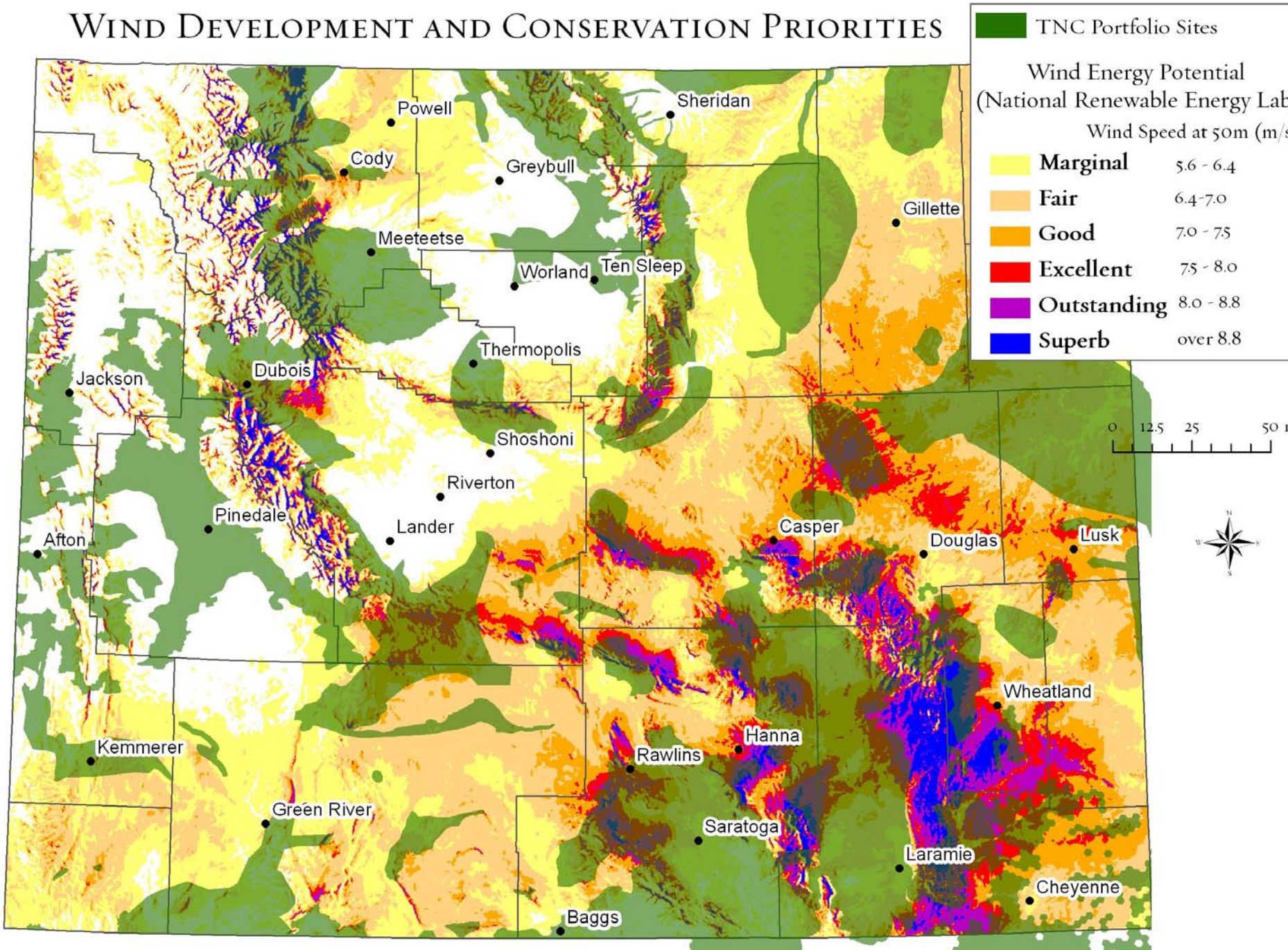
Wind Energy Development Potential in Wyoming



Priority Conservation Areas in Wyoming



Wind Development and Conservation Priorities

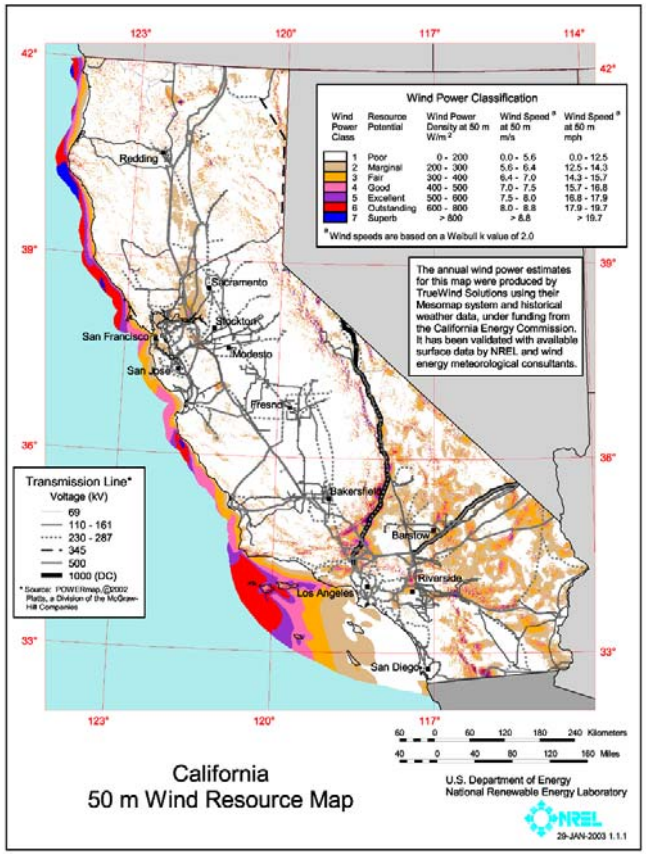


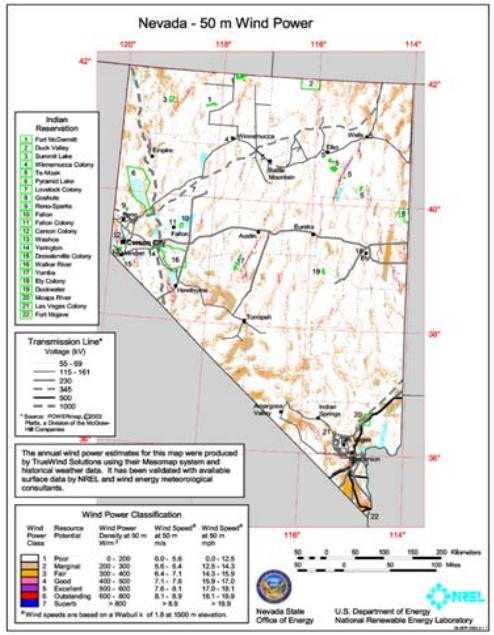
Matching for ecologically equivalency?

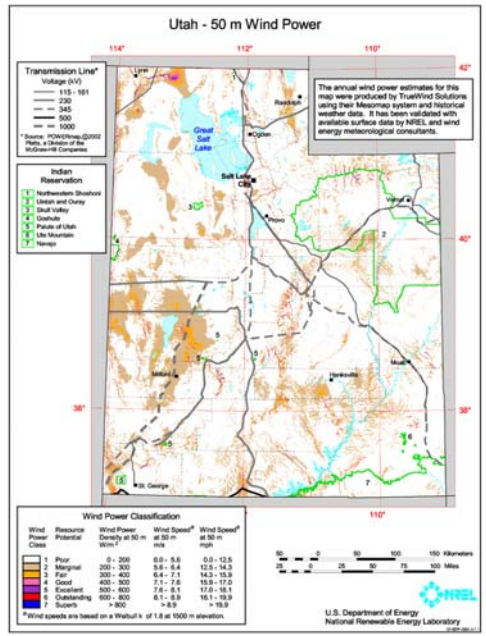
1. Nature Serve Integrity Guidelines
2. USFWS Habitat Evaluation Procedure
3. NRCS Range Sites Index
4. BBOP Benchmark Approach
5. Restoration Success based approach

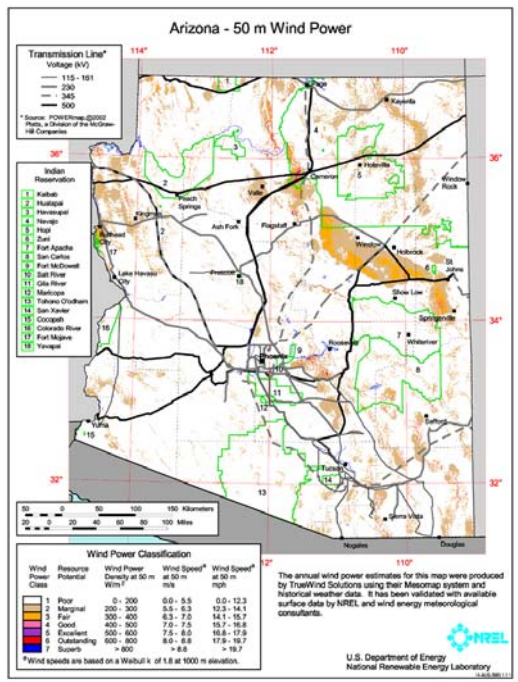
Jonah Mitigation Project Review

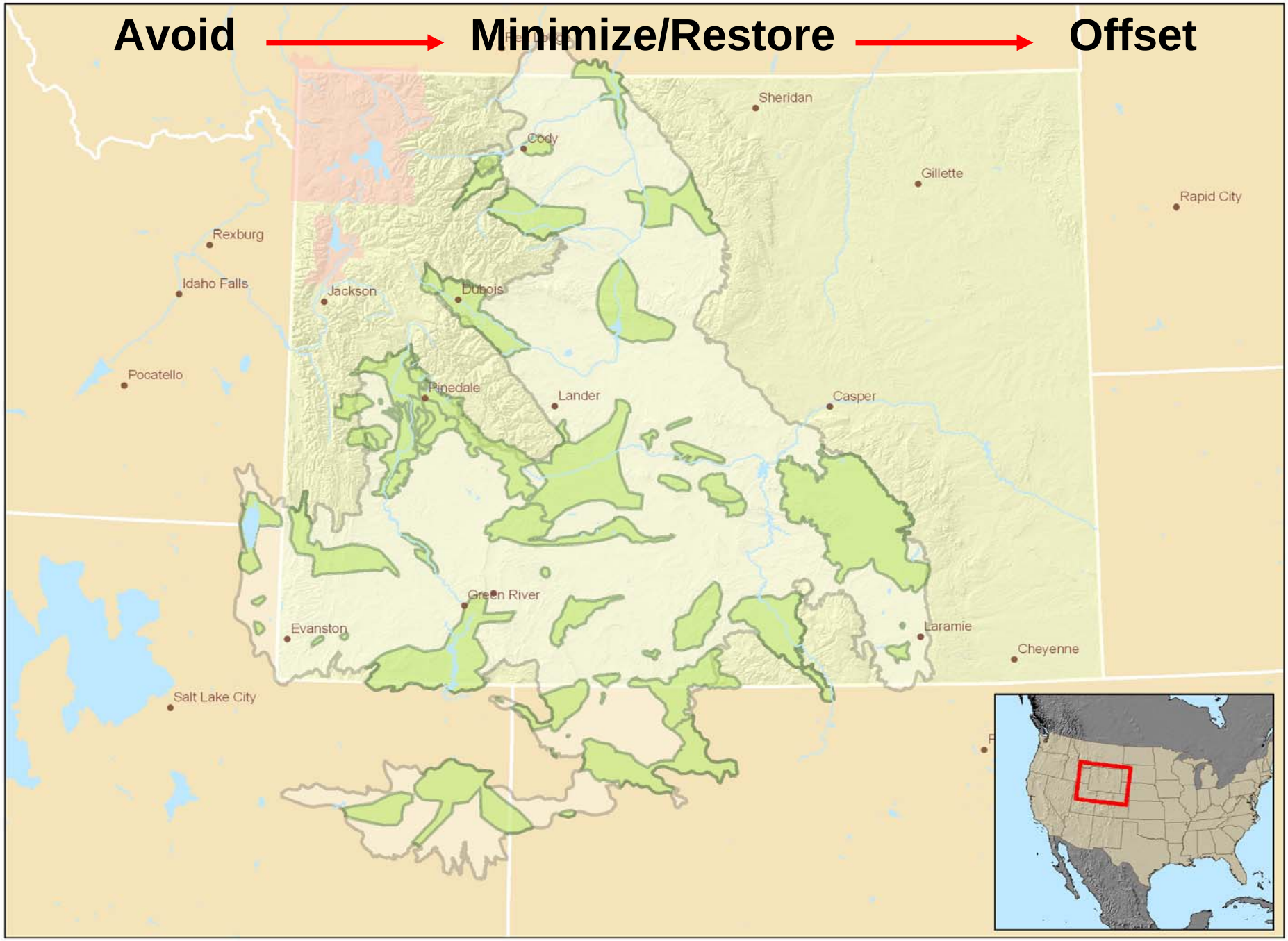
Project	Sage Grouse Leks	Cedar-Rim Thistle (Acres)	Pronghorn Migration (Acres)	Burrowing Owl (Acres)	Prairie Dog Acres	Mountain Plover (Acres)	Pygmy Rabbit (Acres)	Sage Grouse (Acres)	Sagebrush (Acres)	Sage Sparrow (Acres)
Cottonwood Ranch	6	0	8267	4658.4	4658.4	838.4	22564.1	16450.8	17974.8	2294.3
Elk-Mountain Red Canyon Burn	0	49	0	12.8	12.8	25.5	13372.3	406.3	3804.8	372.2
MJ Ranch	6	0	13085	20205.4	20205.4	0	28717.8	36177.7	28153.4	53.1
Murdock	1	0	208	109.8	109.8	0	879.9	482.5	401.1	0
Onion Springs Res. Reclamation Project	0	0	200	234.6	234.6	0	532.6	457.4	485.9	0
Tibbals Reservoir	0	0	374	393.6	393.6	0	413.4	582.8	475.6	0

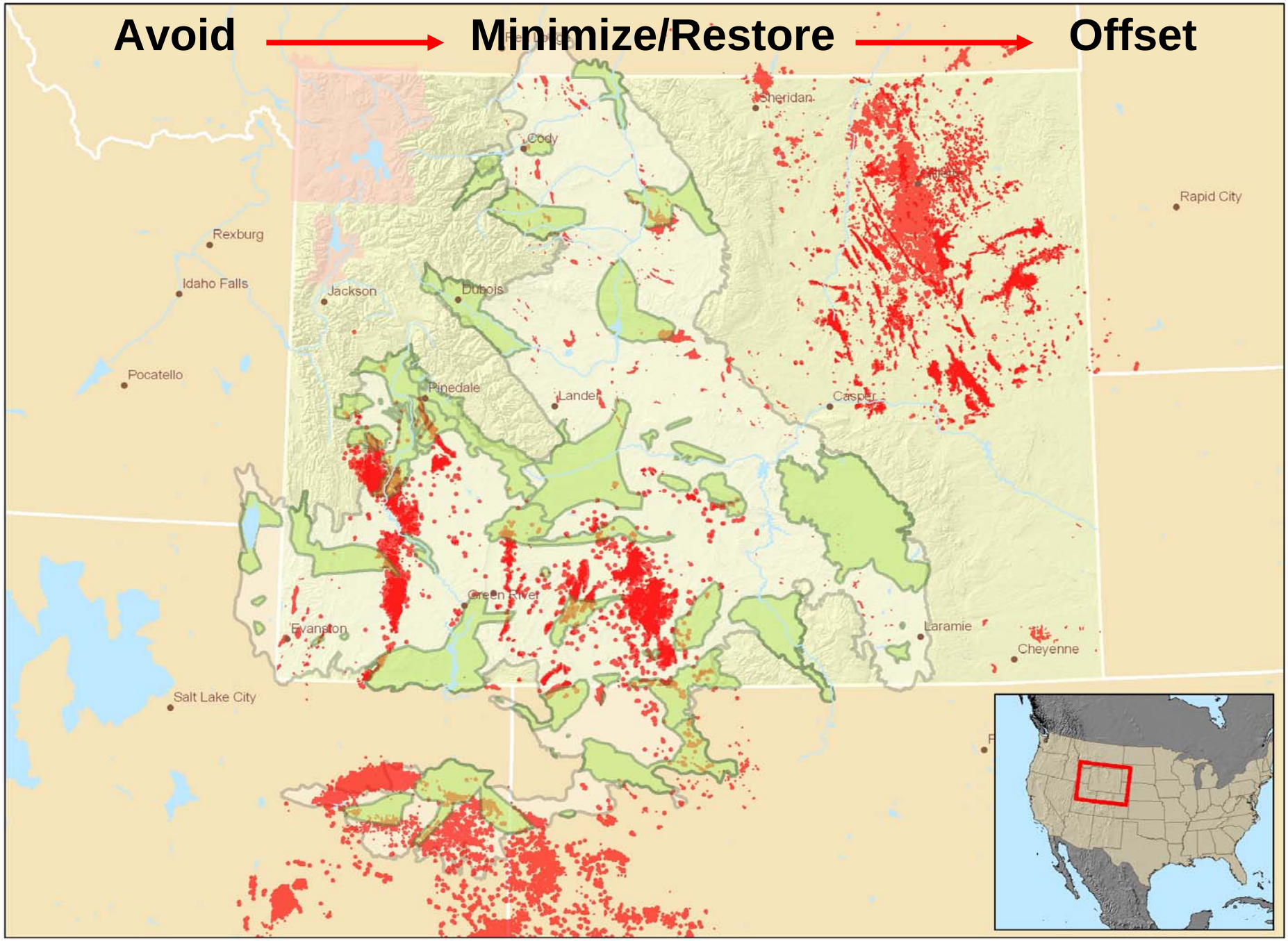

California
50 m Wind Resource Map
Wind Power Classification
Wind Power Class
Resource Potential
Wind Power Density at 50 m W/m2
Wind Speed* at 50 m m/s
Wind Speed* at 50 m mph
1 Poor 0 - 200 0.0 - 5.6 0.0 - 12.5
2 Marginal 200 - 300 5.6 - 6.4 12.5 - 14.3
3 Fair 300 - 400 6.4 - 7.0 14.3 - 15.7
4 Good 400 - 500 7.0 - 7.5 15.7 - 16.8
5 Excellent 500 - 600 7.5 - 8.0 16.8 - 17.9
6 Outstanding 600 - 800 8.0 - 8.8 17.9 - 19.7
7 Superb > 800 > 8.8 > 19.7
* Wind speeds are based on a Weibull k value of 2.0
The annual wind power estimates for this map were produced by TrueWind Solutions using their Mesomap system and historical weather data, under funding from the California Energy Commission. It has been validated with available surface data by NREL and wind energy meteorological consultants.
Transmission Line* Voltage (kV)
69
110 - 161
230 - 287
345
500
1000 (DC)
* Source: POWERmap, ©2002 Platts, a Division of the McGraw-Hill Companies
Redding
Sacramento
Stockton
San Francisco
Modesto
San Jose
Fresno
Bakersfield
Barstow
Riverside
Los Angeles
San Diego
U.S. Department of Energy
National Renewable Energy Laboratory
NREL
29-JAN-2003 1.1.1


Nevada - 50 m Wind Power
Indian Reservation
1 Fort McDermitt
2 Duck Valley
3 Summit Lake
4 Winnemucca Colony
5 Te-Moak
6 Pyramid Lake
7 Lovelock Colony
8 Goshute
9 Reno-Sparks
10 Fallon
11 Fallon Colony
12 Carson Colony
13 Washoe
14 Yerington
15 Dresslerville Colony
16 Walker River
17 Yomba
18 Ely Colony
19 Duckwater
20 Moapa River
21 Las Vegas Colony
22 Fort Mojave
Transmission Line* Voltage (kV)
55 - 69
115 - 161
230
345
500
1000
* Source: POWERmap, ©2002 Platts, a Division of the McGraw-Hill Companies
The annual wind power estimates for this map were produced by TrueWind Solutions using their Mesomap system and historical weather data. It has been validated with available surface data by NREL and wind energy meteorological consultants.
Wind Power Classification
Wind Power Class
Resource Potential
Wind Power Density at 50 m W/m2
Wind Speed* at 50 m m/s
Wind Speed* at 50 m mph
1 Poor 0 - 200 0.0 - 5.6 0.0 - 12.5
2 Marginal 200 - 300 5.6 - 6.4 12.5 - 14.3
3 Fair 300 - 400 6.4 - 7.1 14.3 - 15.9
4 Good 400 - 500 7.1 - 7.6 15.9 - 17.0
5 Excellent 500 - 600 7.6 - 8.1 17.0 - 18.1
6 Outstanding 600 - 800 8.1 - 8.9 18.1 - 19.9
7 Superb > 800 > 8.9 > 19.9
* Wind speeds are based on a Weibull k of 1.8 at 1000 m elevation.
Nevada State Office of Energy
U.S. Department of Energy
National Renewable Energy Laboratory
NREL


Utah - 50 m Wind Power
Transmission Line* Voltage (kV)
115 - 161
230
345
500
1000
* Source: POWERmap, ©2002 Platts, a Division of the McGraw-Hill Companies
The annual wind power estimates for this map were produced by TrueWind Solutions using their Mesomap system and historical weather data. It has been validated with available surface data by NREL and wind energy meteorological consultants.
Indian Reservation
1 Northwestern Shoshoni
2 Uintah and Ouray
3 Skull Valley
4 Goshute
5 Paiute of Utah
6 Ute Mountain
7 Navajo
Great Salt Lake
Salt Lake City
Provo
Ogden
Richfield
Moab
St. George
Wind Power Classification
Wind Power Class
Resource Potential
Wind Power Density at 50 m W/m2
Wind Speed* at 50 m m/s
Wind Speed* at 50 m mph
1 Poor 0 - 200 0.0 - 5.6 0.0 - 12.5
2 Marginal 200 - 300 5.6 - 6.4 12.5 - 14.3
3 Fair 300 - 400 6.4 - 7.1 14.3 - 15.9
4 Good 400 - 500 7.1 - 7.6 15.9 - 17.0
5 Excellent 500 - 600 7.6 - 8.1 17.0 - 18.1
6 Outstanding 600 - 800 8.1 - 8.9 18.1 - 19.9
7 Superb > 800 > 8.9 > 19.9
* Wind speeds are based on a Weibull k of 1.8 at 1500 m elevation.
U.S. Department of Energy
National Renewable Energy Laboratory
NREL


Arizona - 50 m Wind Power
Transmission Line* Voltage (kV)
115 - 161
230
345
500
* Source: POWERmap, ©2002 Platts, a Division of the McGraw-Hill Companies
Indian Reservation
1 Kaibab
2 Hualapai
3 Havasupai
4 Navajo
5 Hopi
6 Zuni
7 Fort Apache
8 San Carlos
9 Fort McDowell
10 Salt River
11 Gila River
12 Maricopa
13 Tohono O'odham
14 San Xavier
15 Cocopah
16 Colorado River
17 Fort Mojave
18 Yavapai
Page
Kayenta
Holbrook
Cameron
Window Rock
Chinle
Fredonia
Kanab
Valle
Peach Springs
Ash Fork
Flagstaff
Williams
Winslow
Kaibab Ind. Res.
Grand Canyon
Lake Havasu City
Prescott
St. Johns
Show Low
Springerville
Roosevelt
Whiteriver
Phoenix
Tonto
Superior
Yuma
Tucson
Sierra Vista
Nogales
Douglas
Wind Power Classification
Wind Power Class
Resource Potential
Wind Power Density at 50 m W/m2
Wind Speed* at 50 m m/s
Wind Speed* at 50 m mph
1 Poor 0 - 200 0.0 - 5.5 0.0 - 12.3
2 Marginal 200 - 300 5.5 - 6.3 12.3 - 14.1
3 Fair 300 - 400 6.3 - 7.0 14.1 - 15.7
4 Good 400 - 500 7.0 - 7.5 15.7 - 16.8
5 Excellent 500 - 600 7.5 - 8.0 16.8 - 17.9
6 Outstanding 600 - 800 8.0 - 8.8 17.9 - 19.7
7 Superb > 800 > 8.8 > 19.7
* Wind speeds are based on a Weibull k of 1.8 at 1000 m elevation.
The annual wind power estimates for this map were produced by TrueWind Solutions using their Mesomap system and historical weather data. It has been validated with available surface data by NREL and wind energy meteorological consultants.
U.S. Department of Energy
National Renewable Energy Laboratory
NREL


Avoid
Minimize/Restore
Offset
Sheridan
Cody
Gillette
Rapid City
Rexburg
Idaho Falls
Jackson
Dubois
Pocatello
Pinedale
Lander
Casper
Green River
Evanston
Laramie
Cheyenne
Salt Lake City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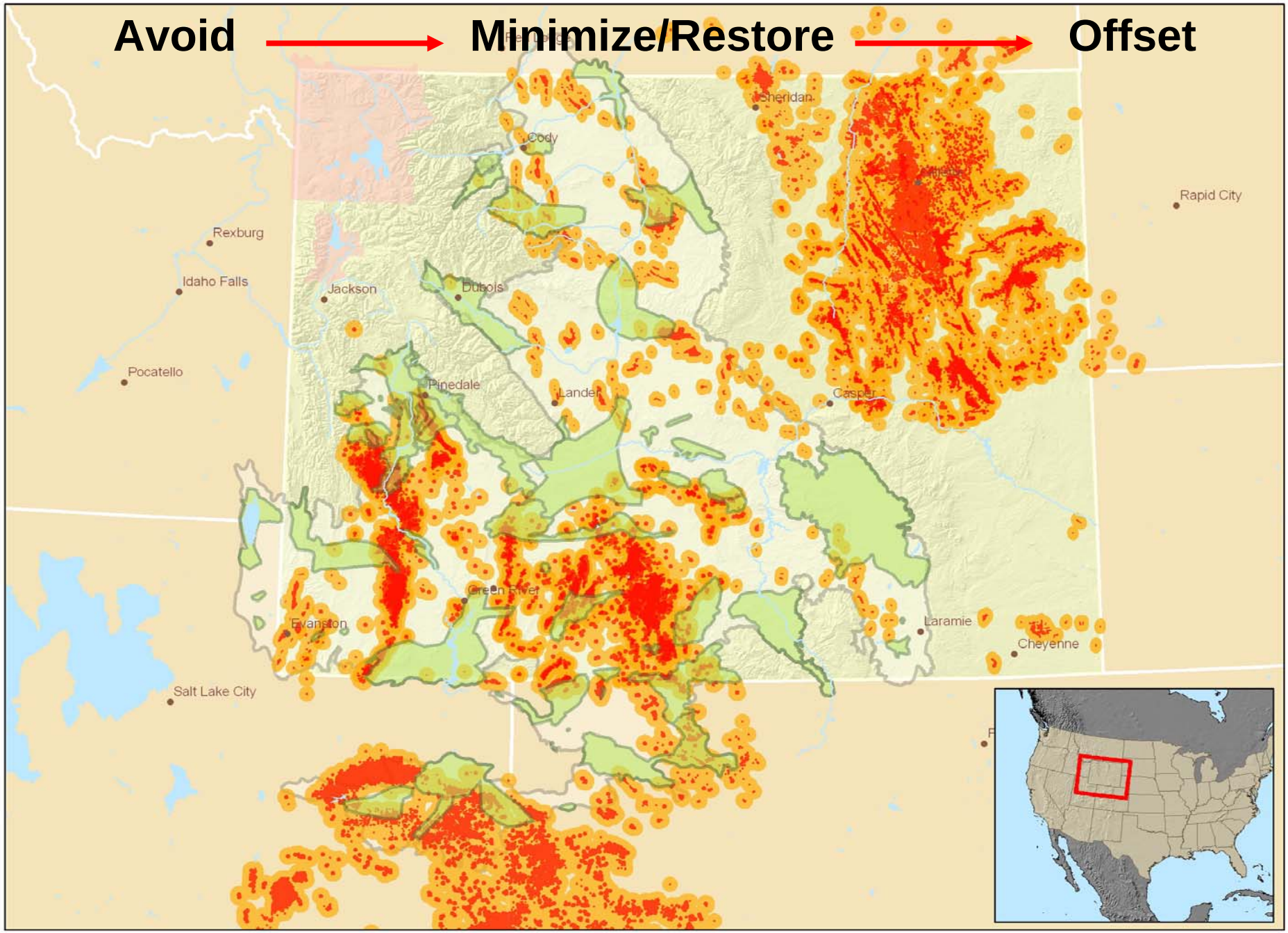
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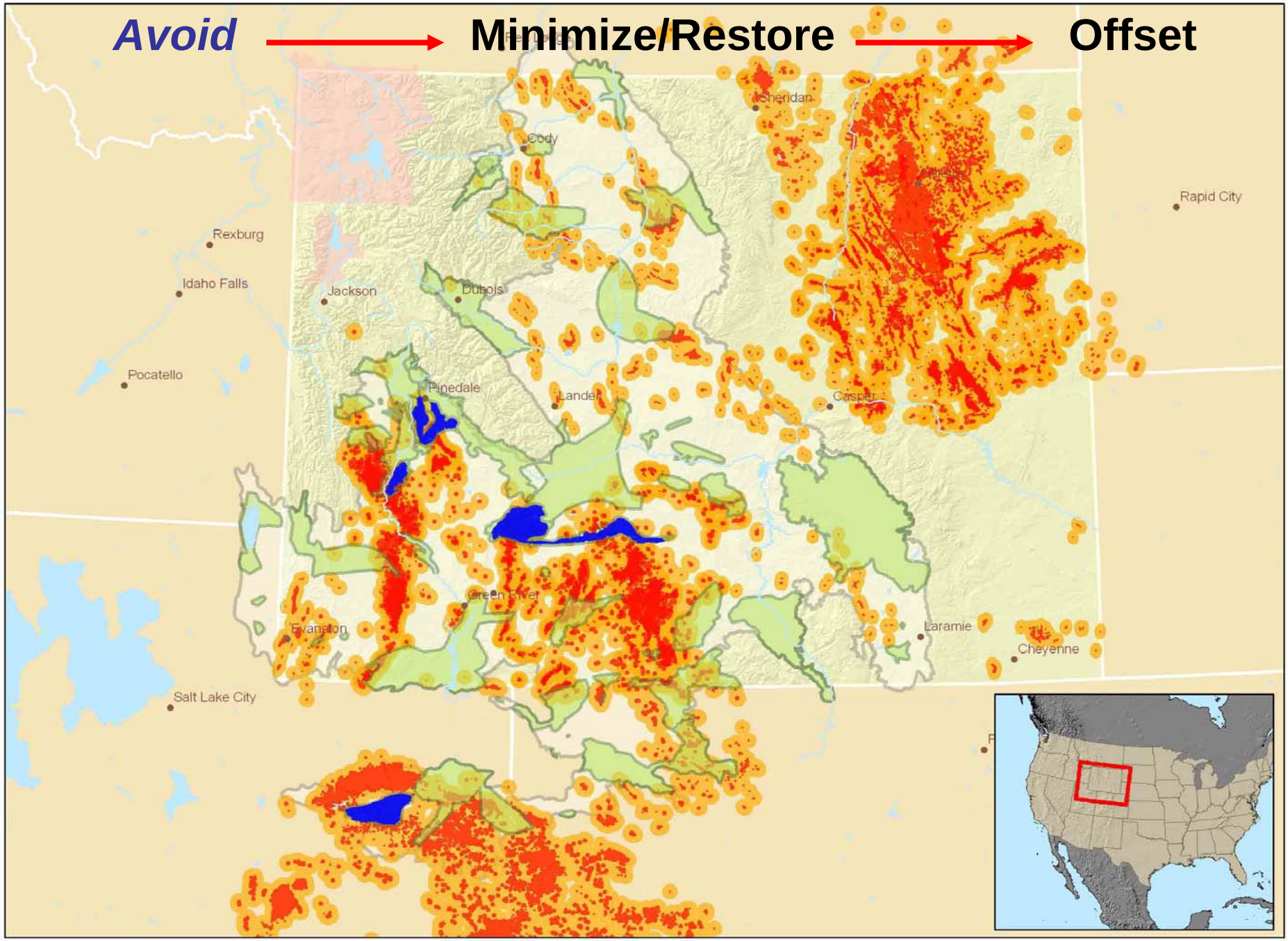
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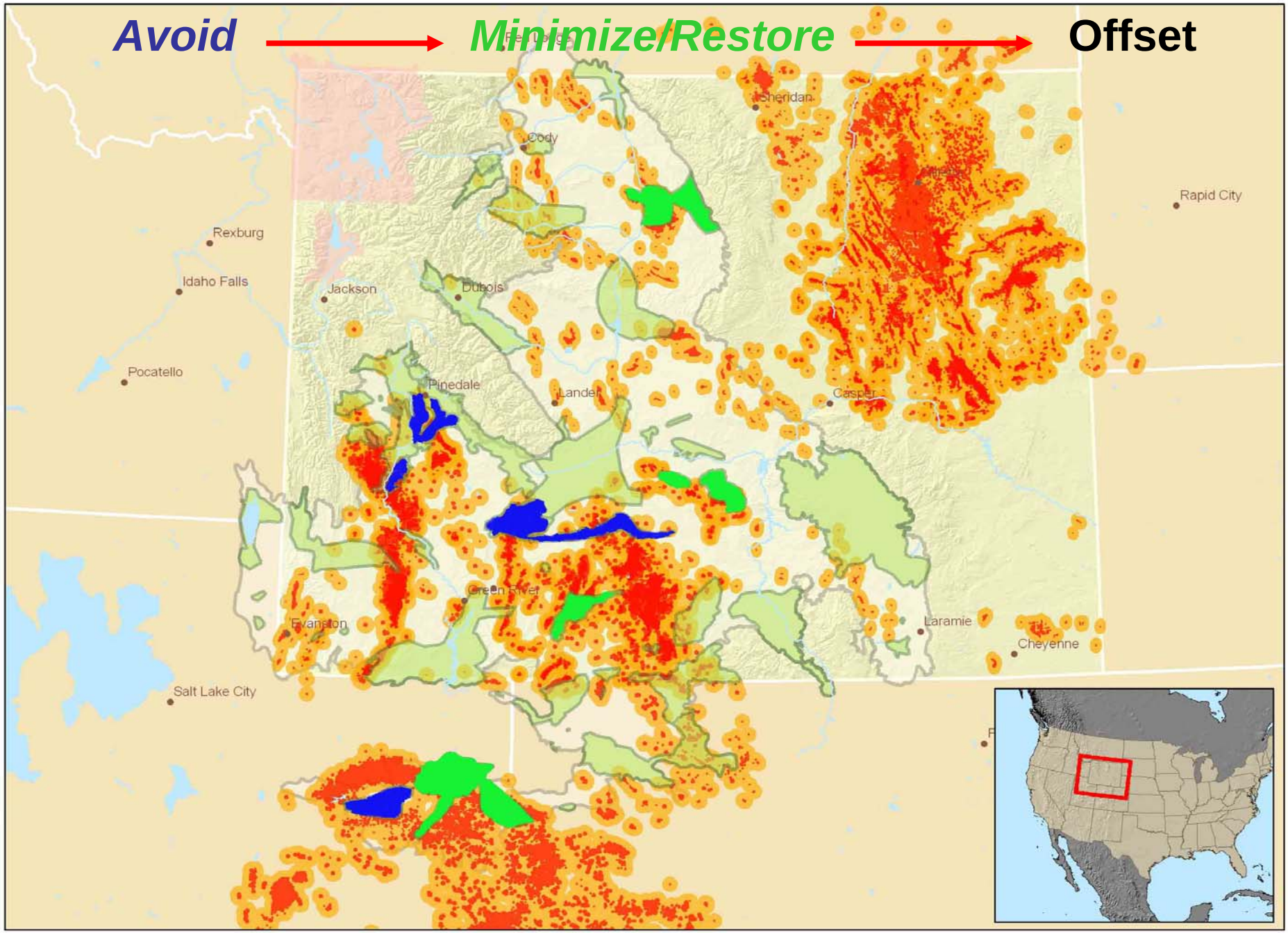
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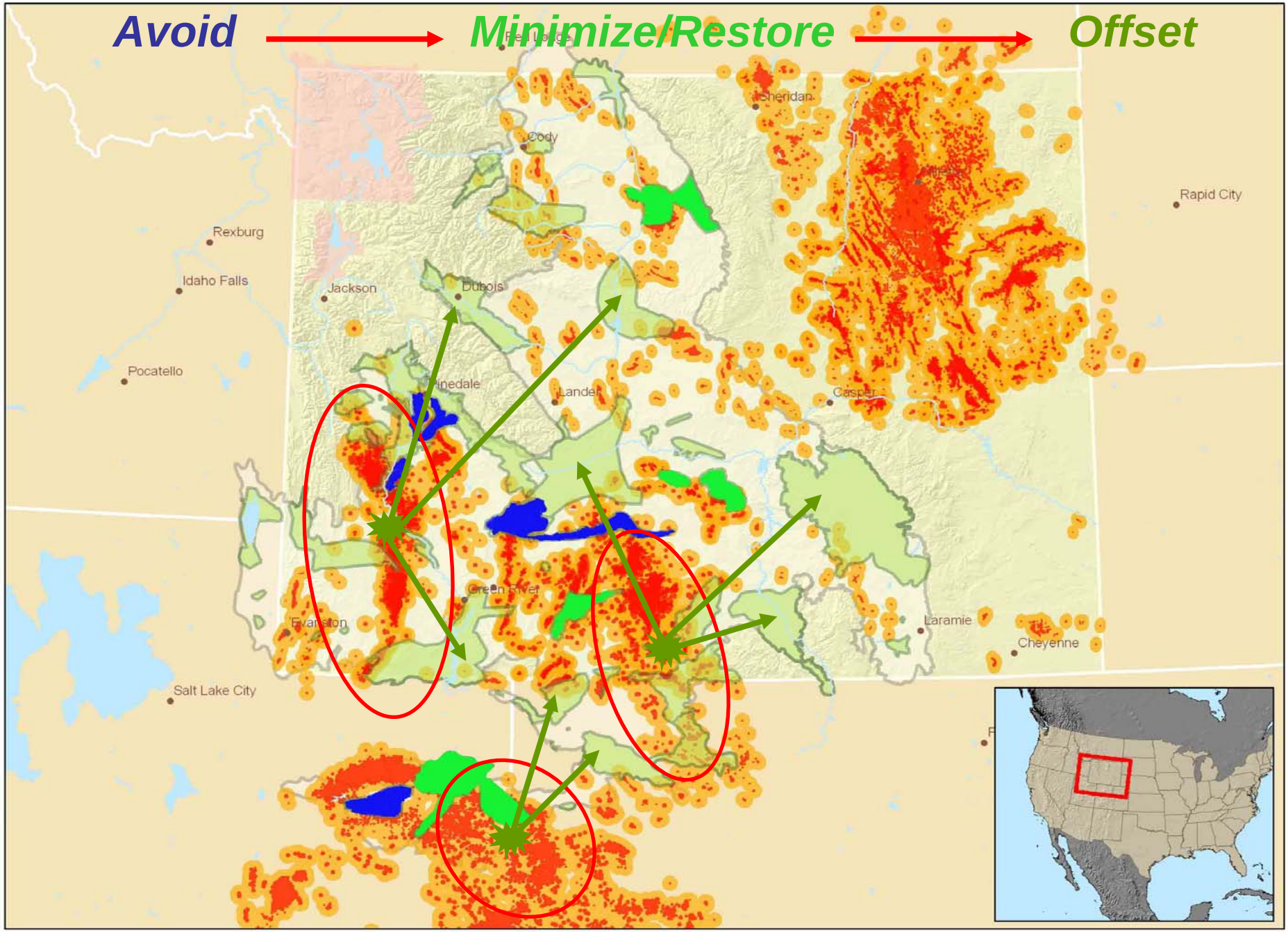
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Dubois
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Pinedale
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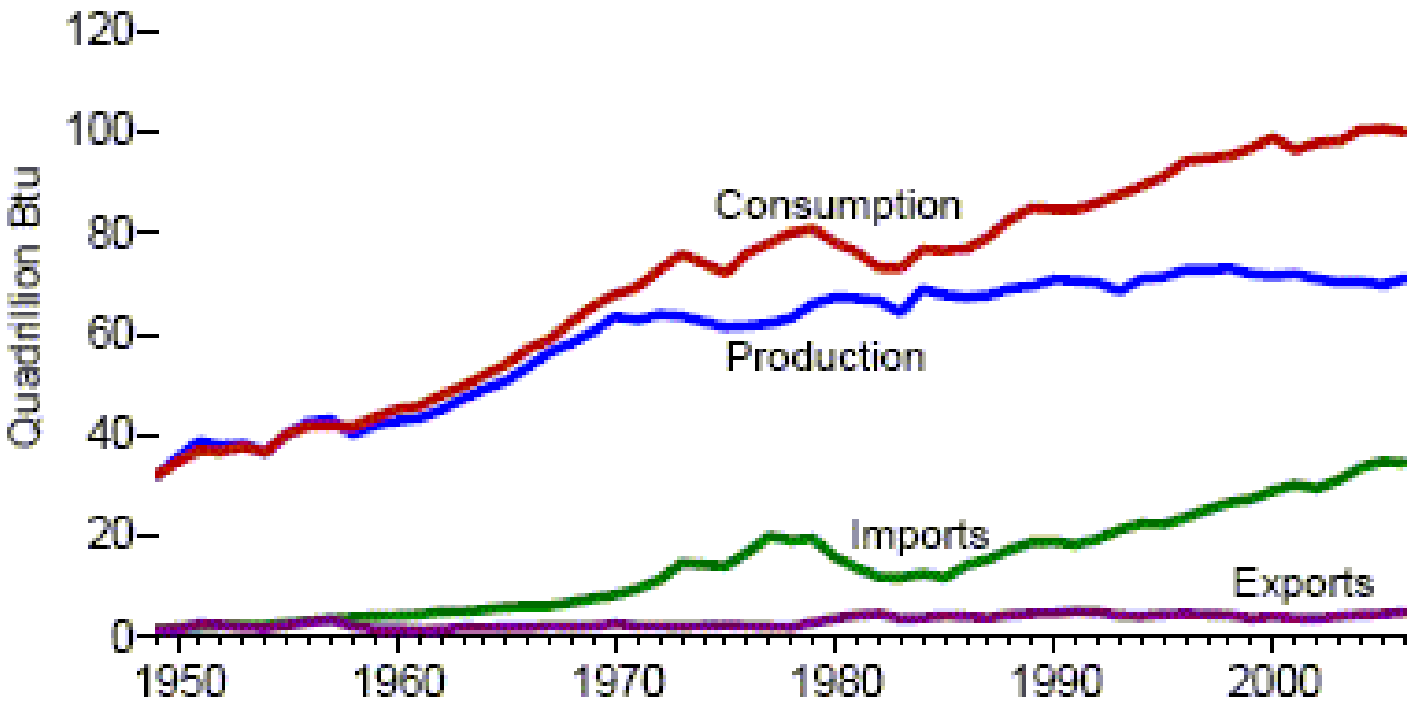
Laramie
Cheyenne
Salt Lake City


Quadrillion Btu
120
100
80
60
40
20
0
1950
1960
1970
1980
1990
2000
Consumption
Production
Imports
Exports

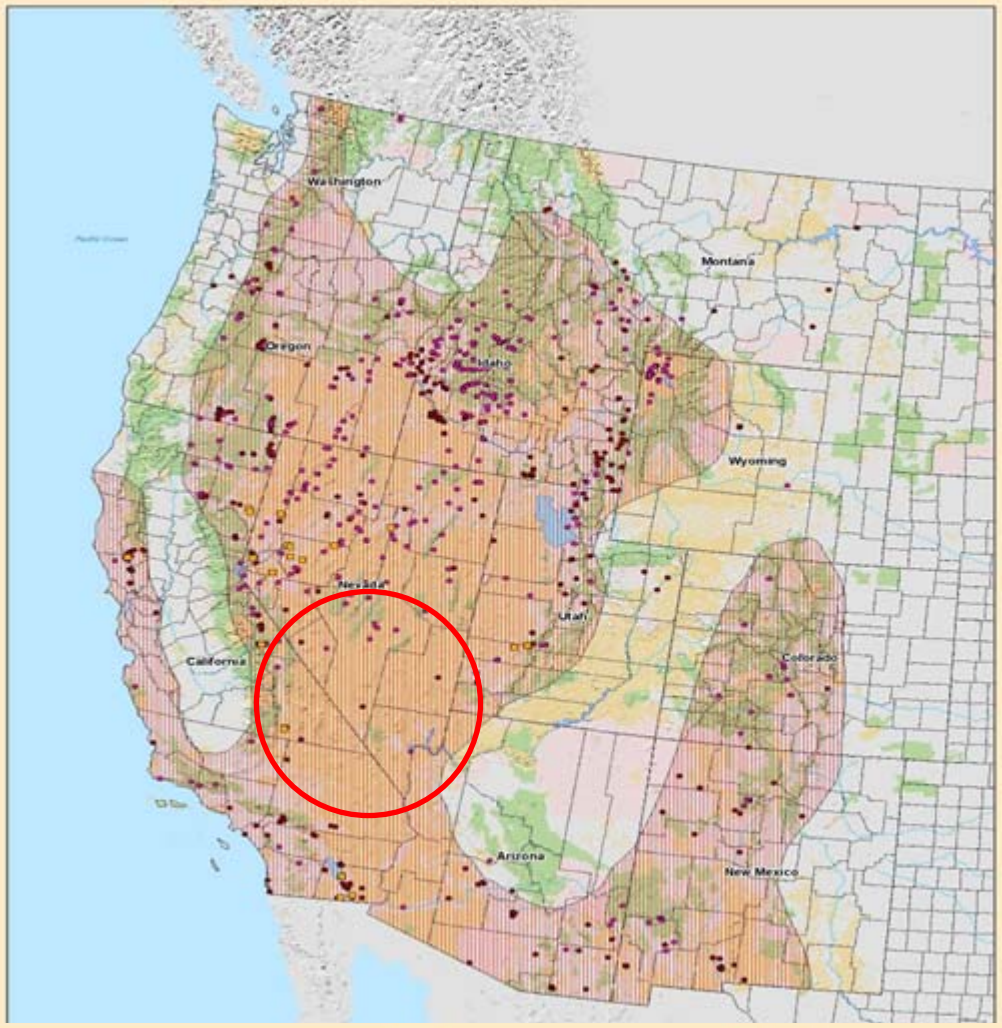
The United States is the largest energy consumer in terms of total use, using 100 quadrillion BTU:
(29,000 TW = 29,000,000,000 MW = 29,000,000,000,000 KW) in 2005

The majority of this energy is derived from fossil fuels:
40% Petroleum
23% Coal
23% Natural Gas

The remaining 14%:

- Nuclear Power
- Hyrdoelectric Dams
- Miscellaneous Renewable Energy (~3%)

Western United States Geothermal Resources



Legend

- Rivers/Streams
- County Boundaries
- State Boundaries
- Lakes/Reservoirs

Geothermal Categories

- Electrical Generation
- Regions of Known or Potential Geothermal Resources
- Wells > 50 Degrees C
- Springs > 50 Degrees C

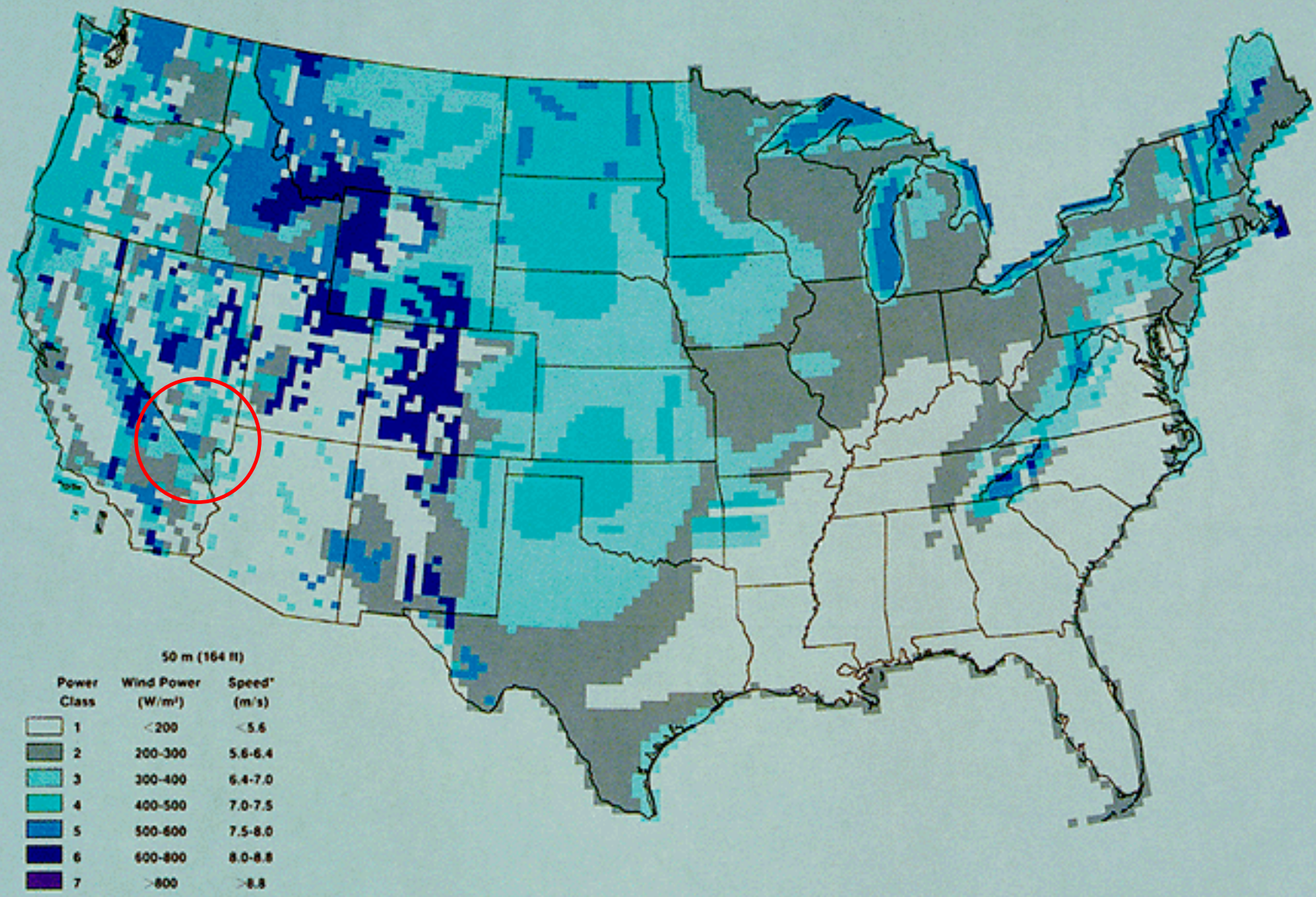
Ownership

- State and Private Lands
- Bureau of Land Management and Other Federal Lands
- Major Lakes and Reserviors
- Native American Lands
- U.S. Forest Service Lands

Map Prepared by Patrick Laney and Julie Brizzee at the Idaho National Engineering and Environmental Laboratory
For
The U.S. Department of Energy Office of Energy Efficiency and Renewable Energy Geothermal Technologies Program

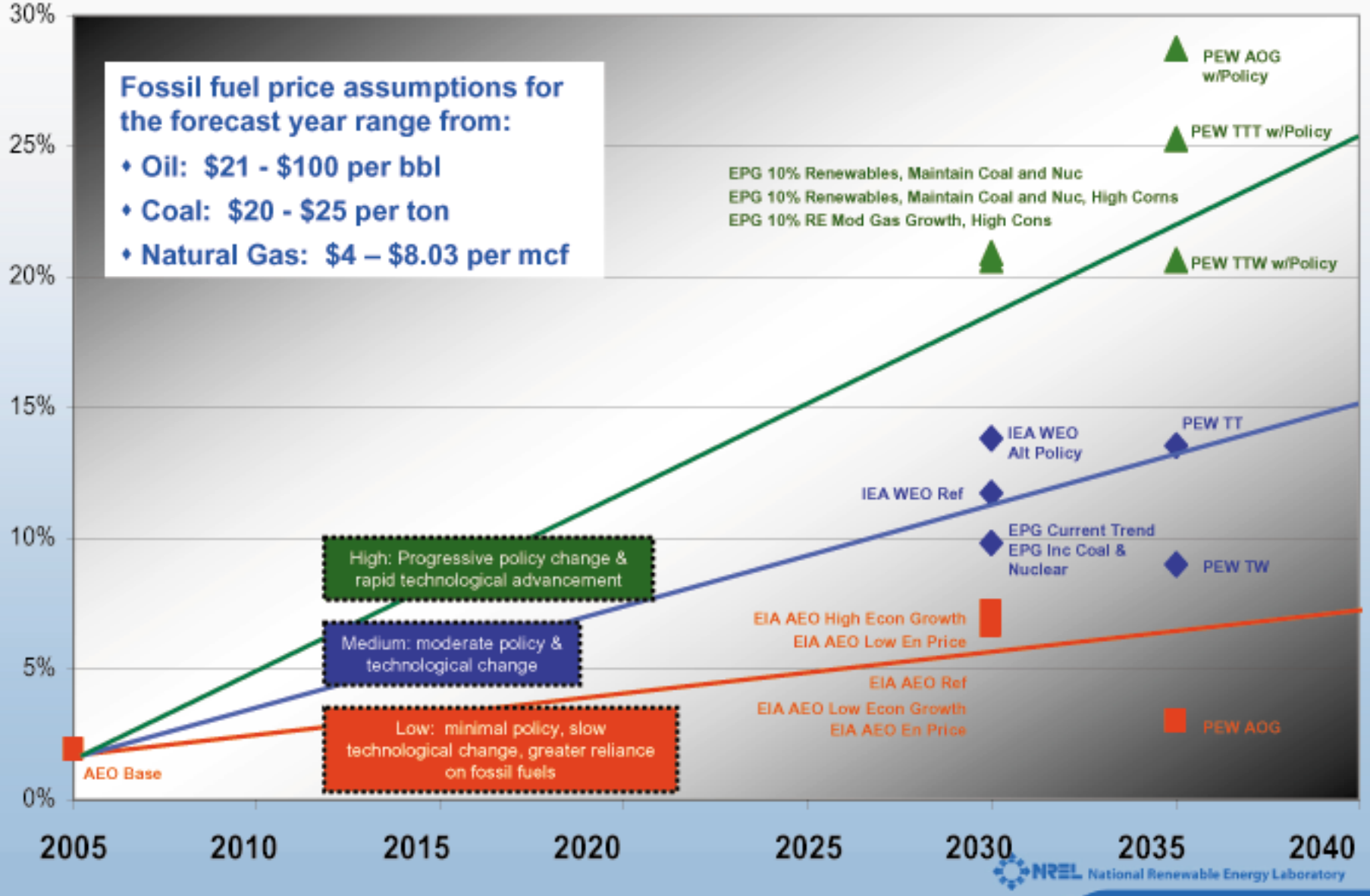
Western United States Geothermal Resources
Publication No. - INEEL/MISC-0301046 Rev. 1
November 2003

Map Projection Information:
Projection: Albers
Central Meridian: -96.00
Standard Parallel 1: 20.00
Standard Parallel 2: 60.00
Latitude Of Origin: 40.00


50 m (164 ft)
Power Class
Wind Power (W/m²)
Speed* (m/s)
1 <200 <5.6
2 200-300 5.6-6.4
3 300-400 6.4-7.0
4 400-500 7.0-7.5
5 500-600 7.5-8.0
6 600-800 8.0-8.8
7 >800 >8.8
*Equivalent wind speed at sea level for a Rayleigh distribution.

U.S. Renewable Energy Contributions

Percent of Total Electric Generating Capacity



Mitigation Design Questions

1. How do you identify suitable offset sites?
2. How do you ensure offsite mitigation, compensates for onsite impacts?
3. How do you confirm offsets are ecologically equivalent?
4. Once offset sites are located how do you identify appropriate mitigation actions?
5. How do you ensure offsite mitigation conforms to the mitigation hierarchy ?