Oregon State University
College of Forestry

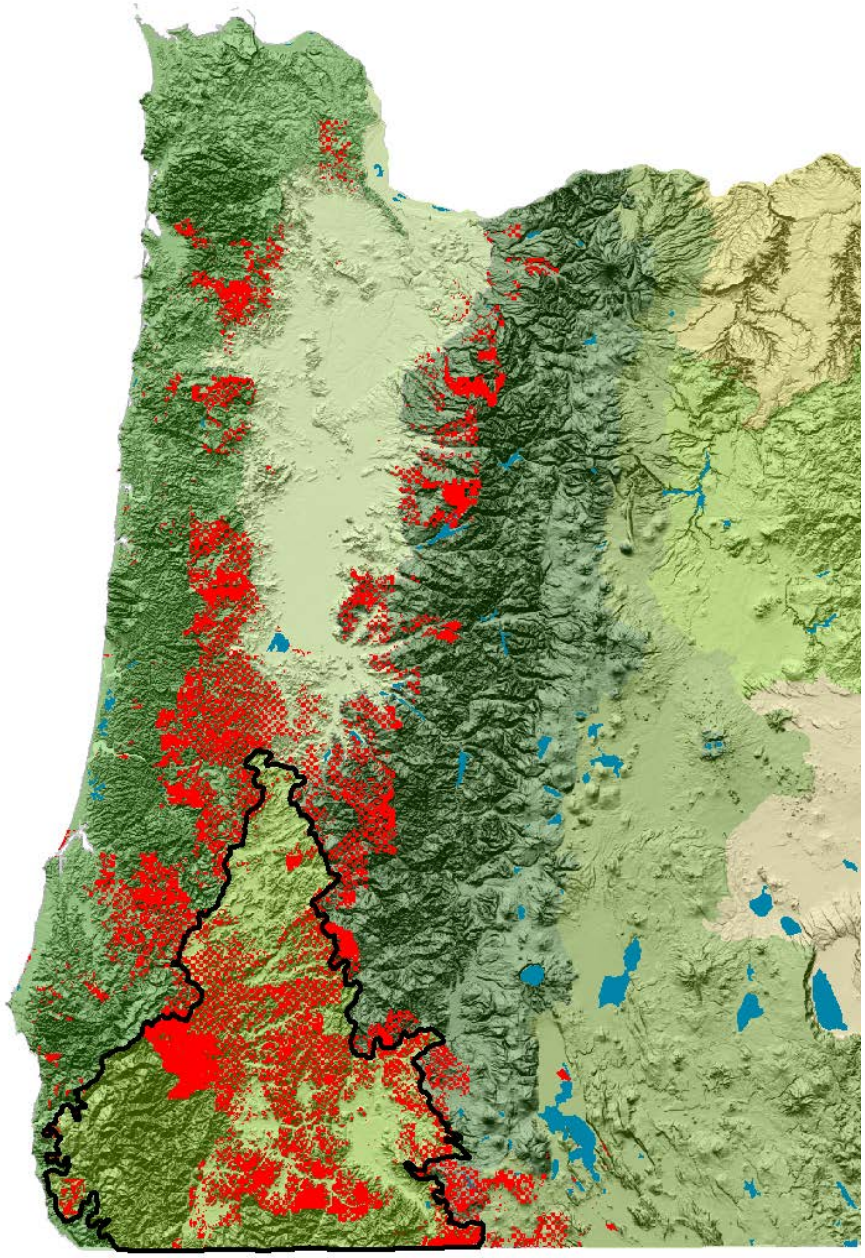
Fire severity patterns across ownership boundaries

Christopher J. Dunn, Oregon State University, Corvallis, OR.
Harold S. Zald, Humboldt State University, Arcata, CA.
Dave E. Calkin, Rocky Mountain Research Station, Missoula, MT.
Mathew P. Thompson, Rocky Mountain Research Station, Missoula, MT.

O & C Lands of Oregon and private industrial forestlands

The O&C Act means that BLM O&C lands must be managed to produce timber.

The Northwest Forest Plan means that the BLM O&C lands must be managed for conservation needs, at least until a new plan is fully implemented



Fire in mixed-ownership landscapes

Fires do not acknowledge ownership boundaries

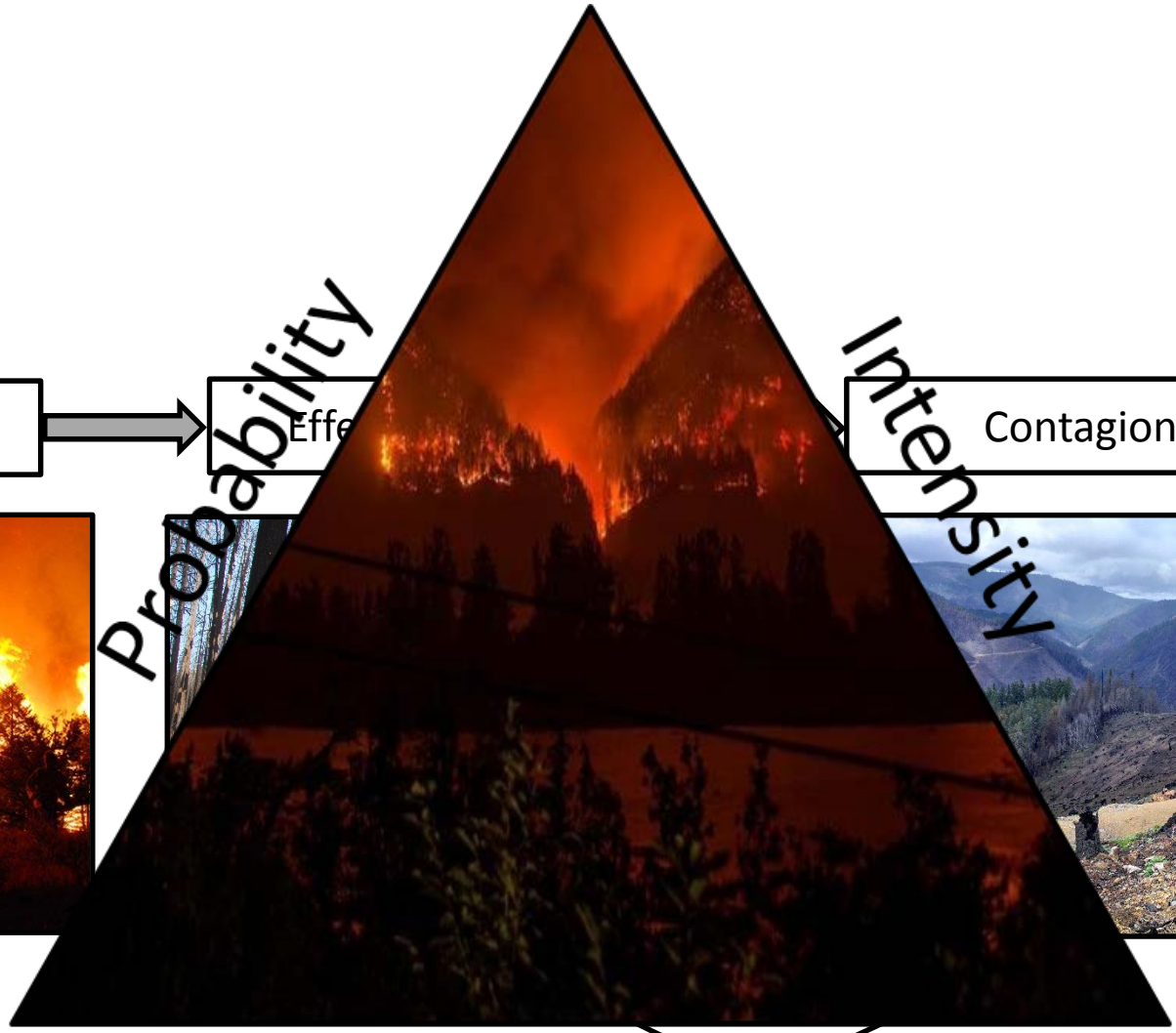
Increasing risk and potential liability

Increasing concern for firefighter safety

Lack of understanding how various forest management regimes influence fire

Wildfire risk

Ignitions → Escape → Effe → Contagion



Probability of occurrence

Susceptibility

Severity
(intensity and susceptibility)

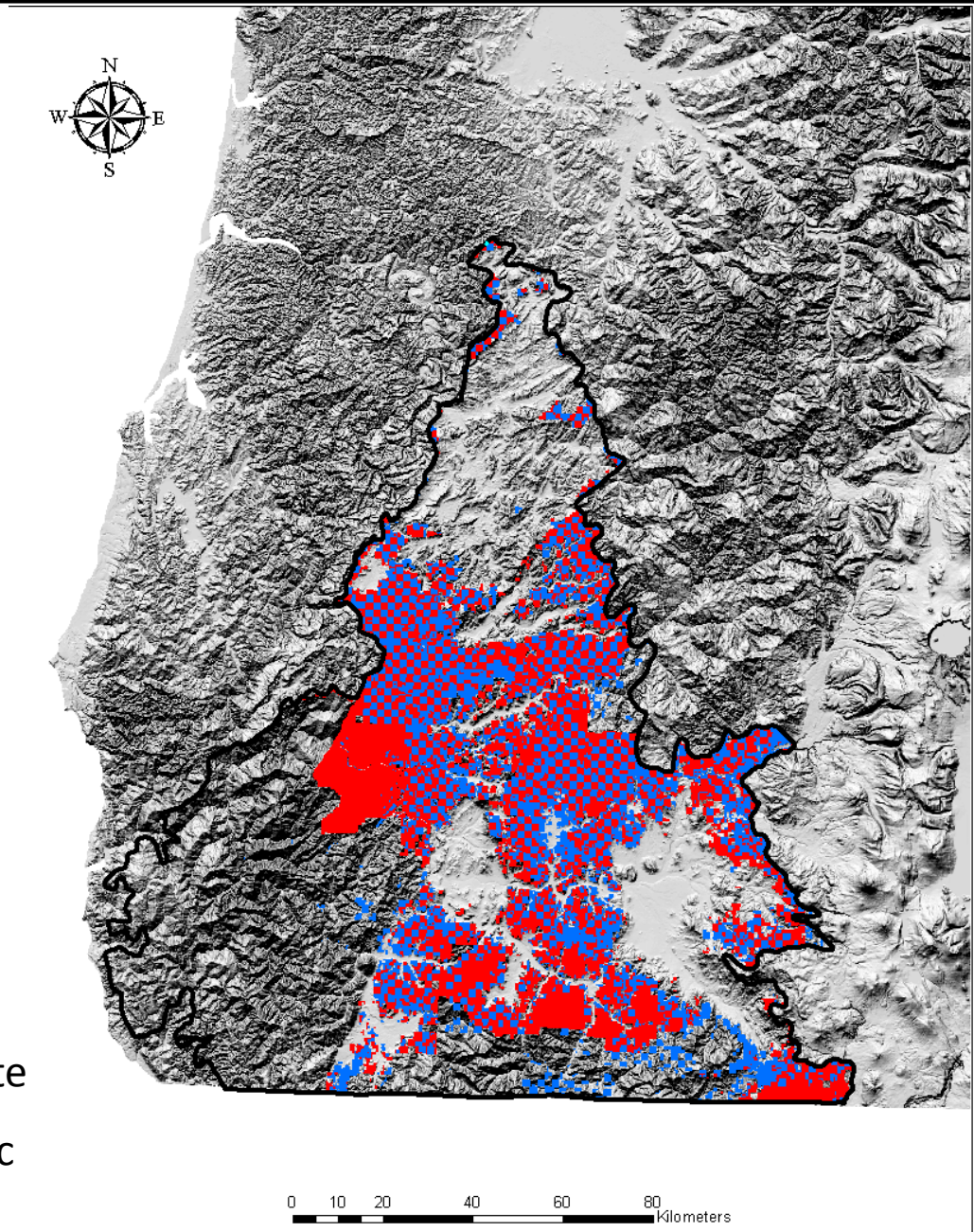
Fire-prone landscape

Klamath Mts. Ecoregion

- Interior lands only
- BLM = 823,891 ac
- Private timber = 650,870 ac

Oregon Department of Forestry responsible for fire suppression

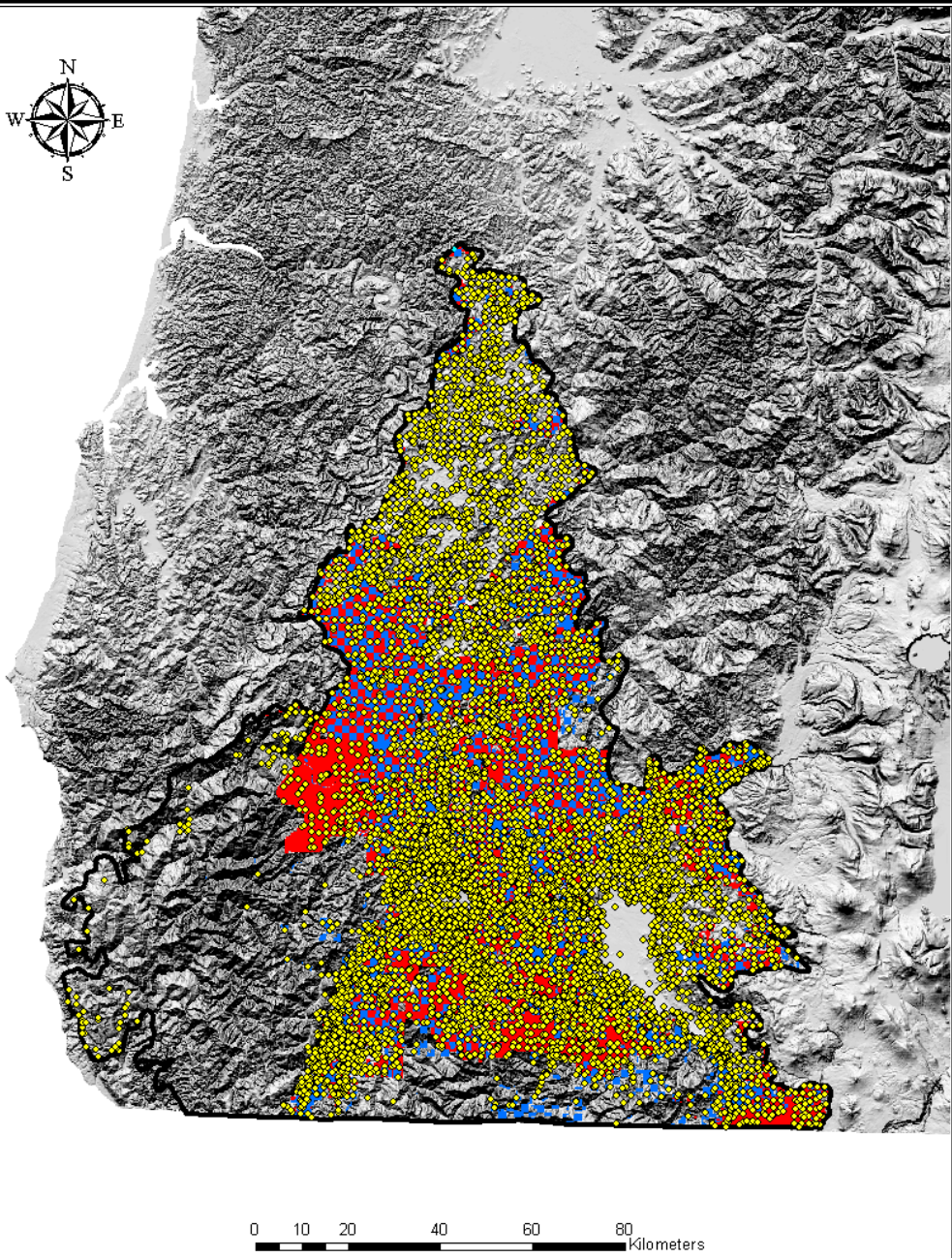
- Aggressive suppression response
- Every acre counts



Ignitions/Escape

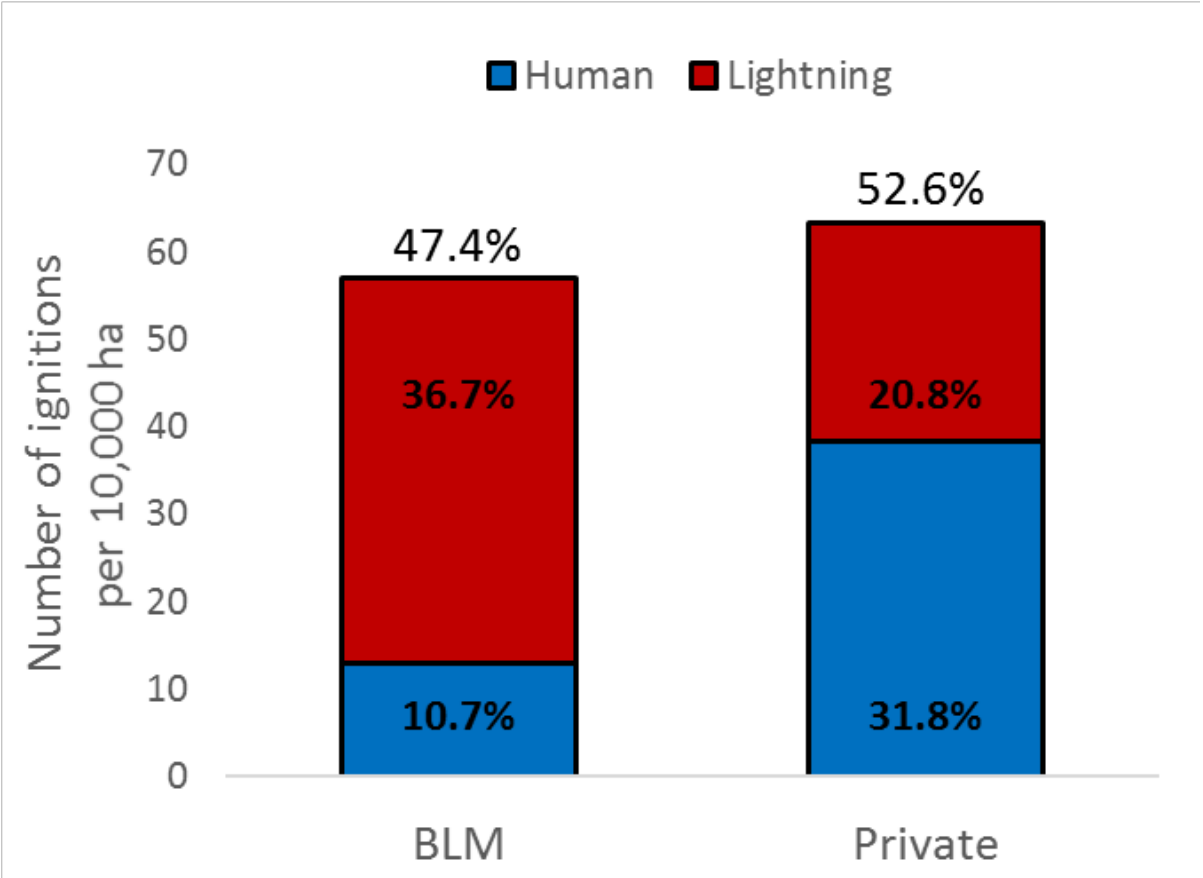
1967 – 2015 ODF fires

Averaged ~75 ignitions per year during summer months on BLM or private timber lands

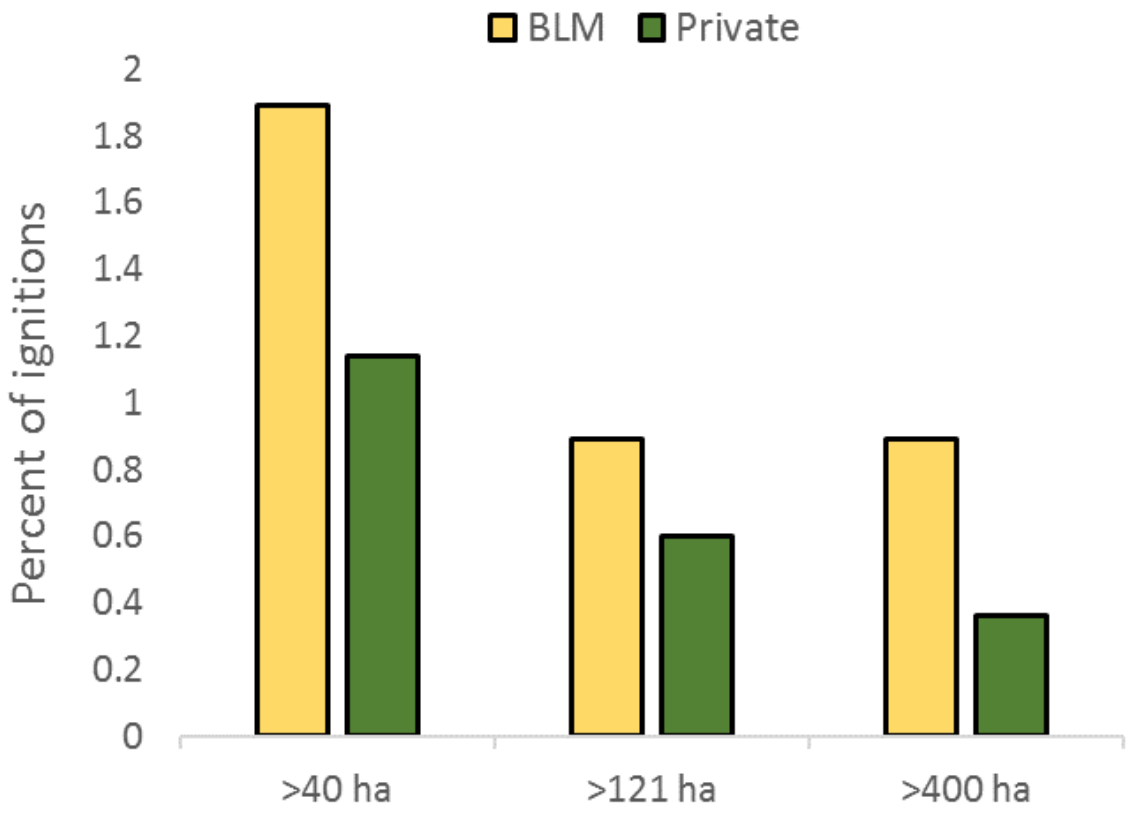


Ignitions/Escape

Scaled by land base



Escaped fires

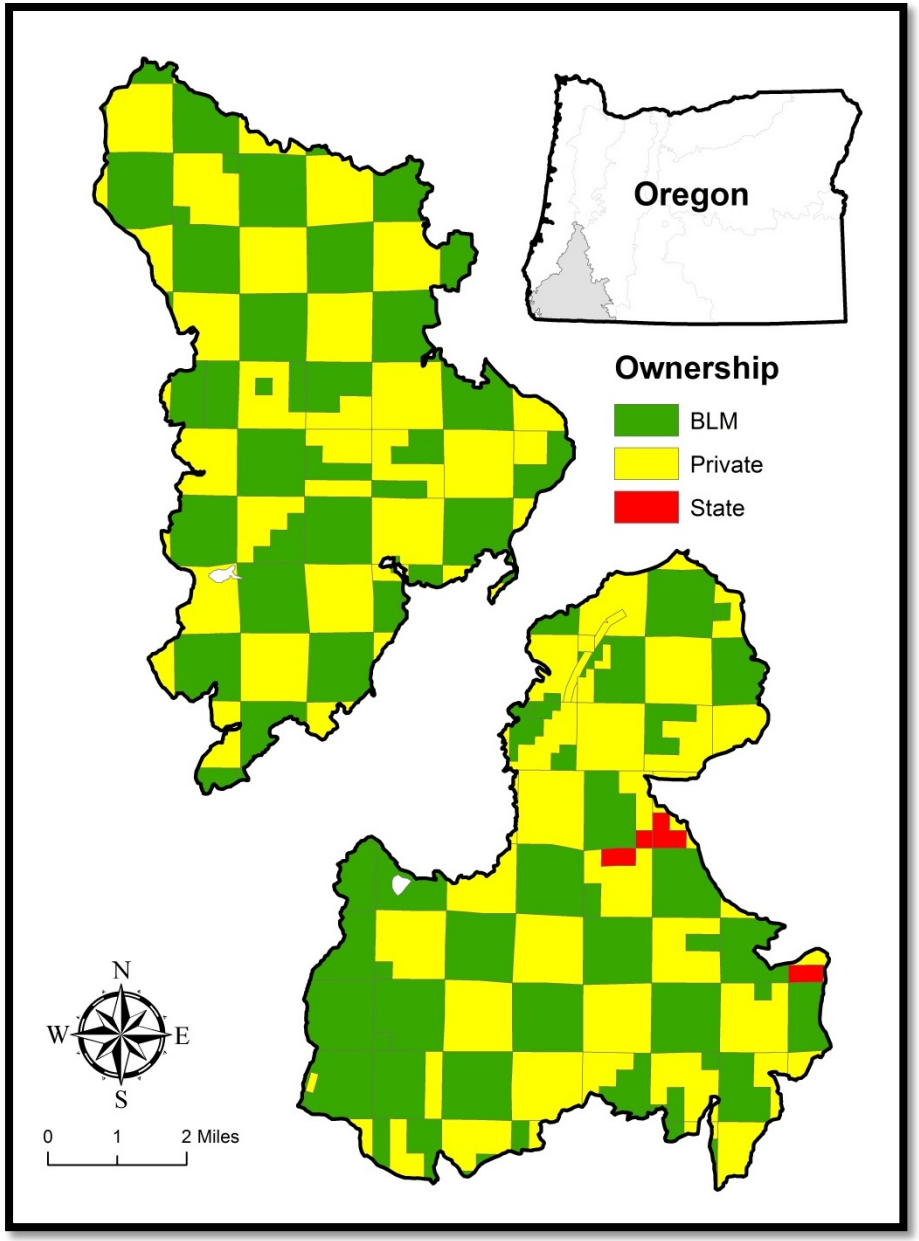


2013 Douglas Complex

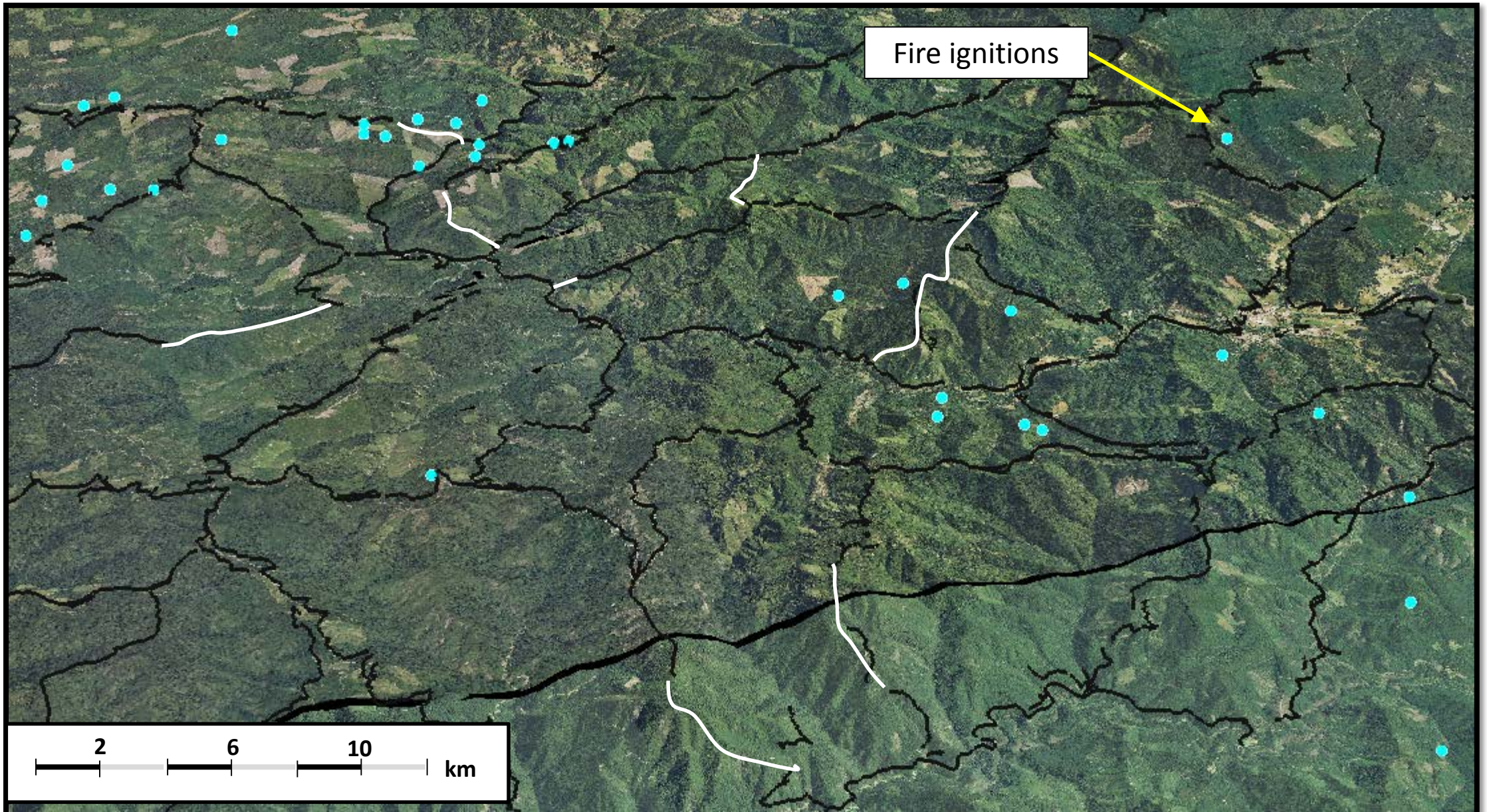
- July 26 – August 20
- Dads Creek & Rabbit Mountain
- 48,920 ac
  - 51.6% BLM = 25,264 ac
  - 48.4% Private industrial = 23,655 ac

- $50 M suppression costs (ODF in 2013)
- $300 M estimated timber loss

- Private: Young, intensively managed plantations
- BLM & State: Older, diverse objectives

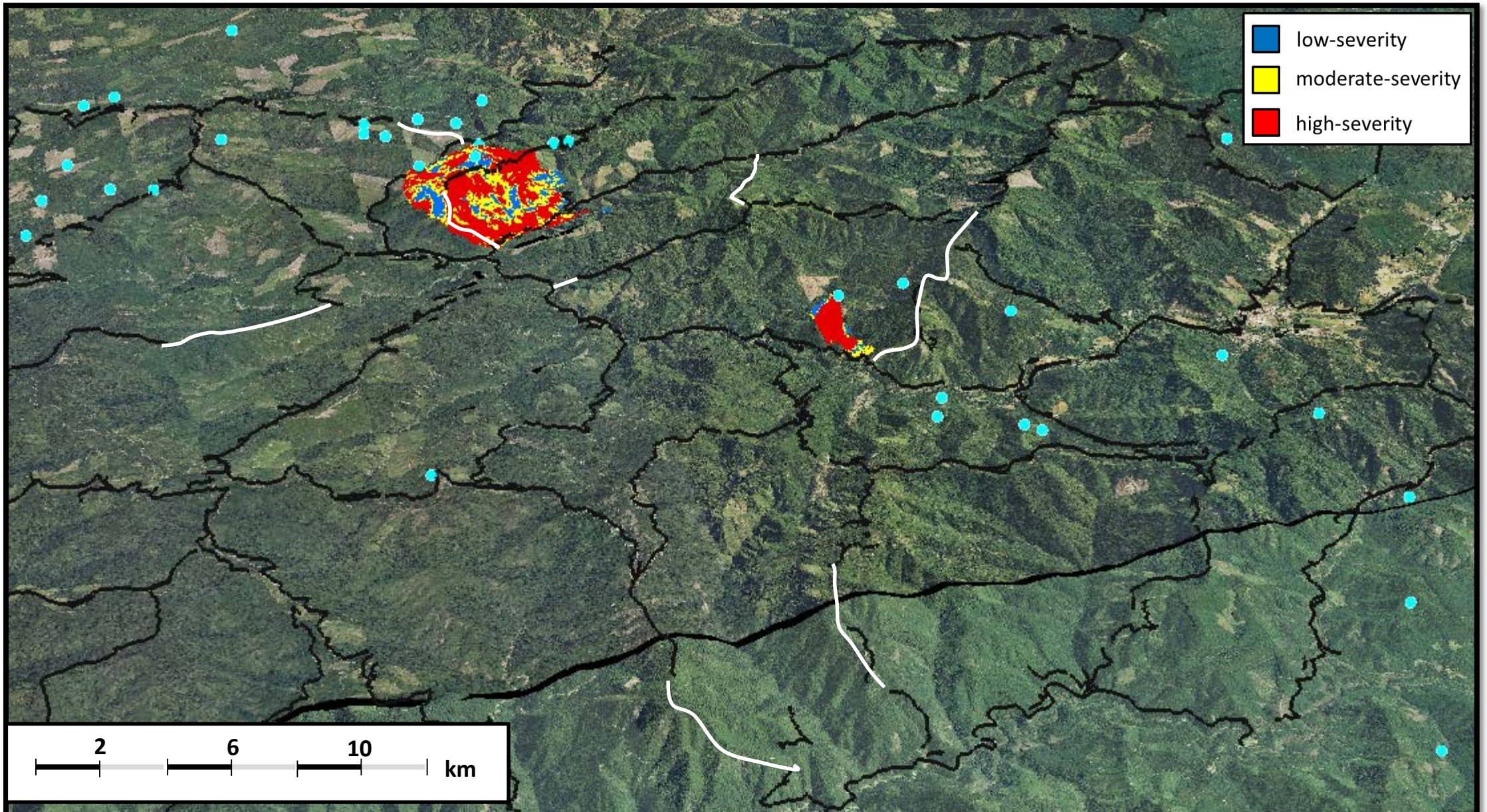


July 26th, 2013



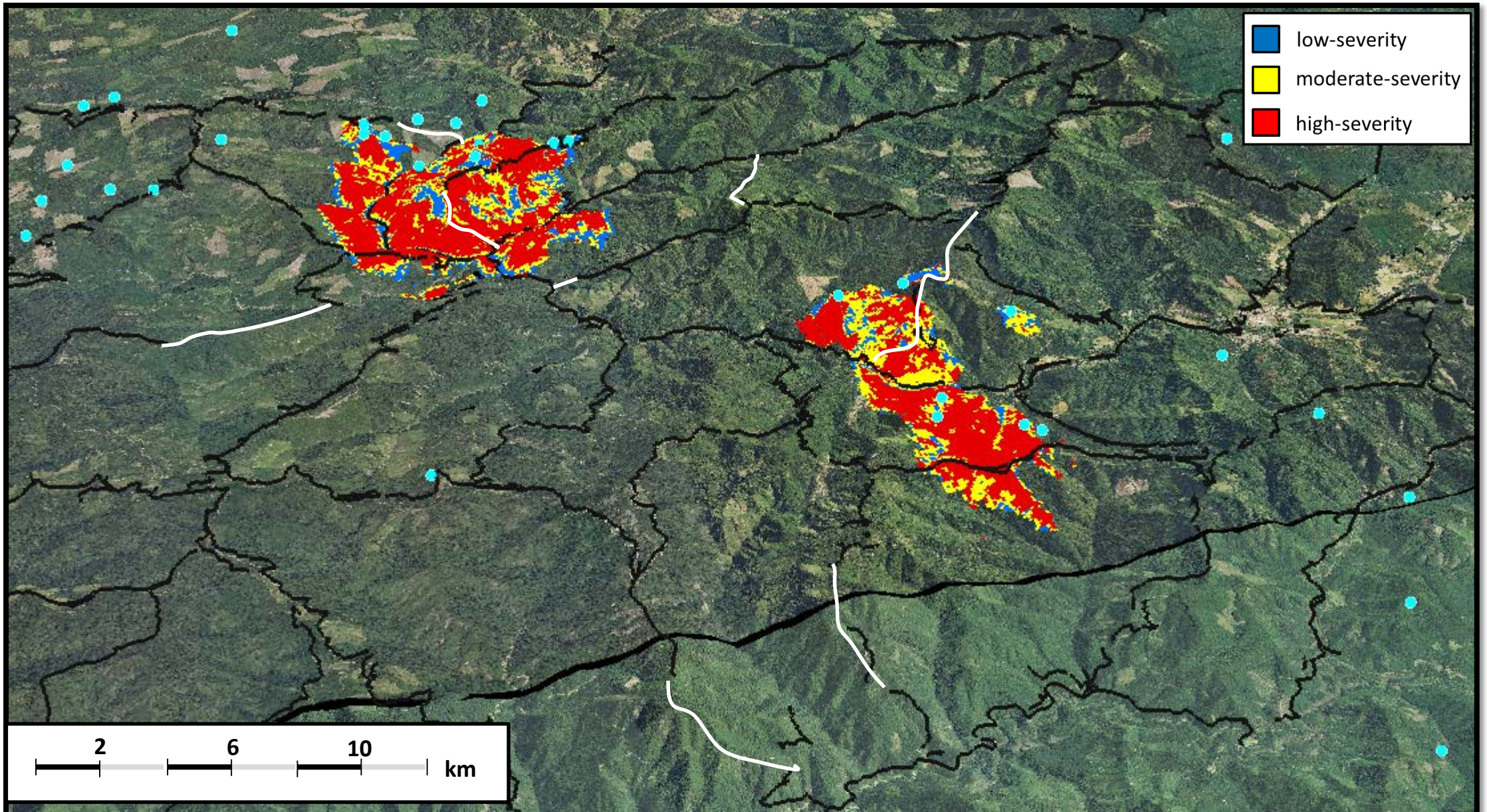
July 26th, 2013

Cumulative area: 3,400 ac



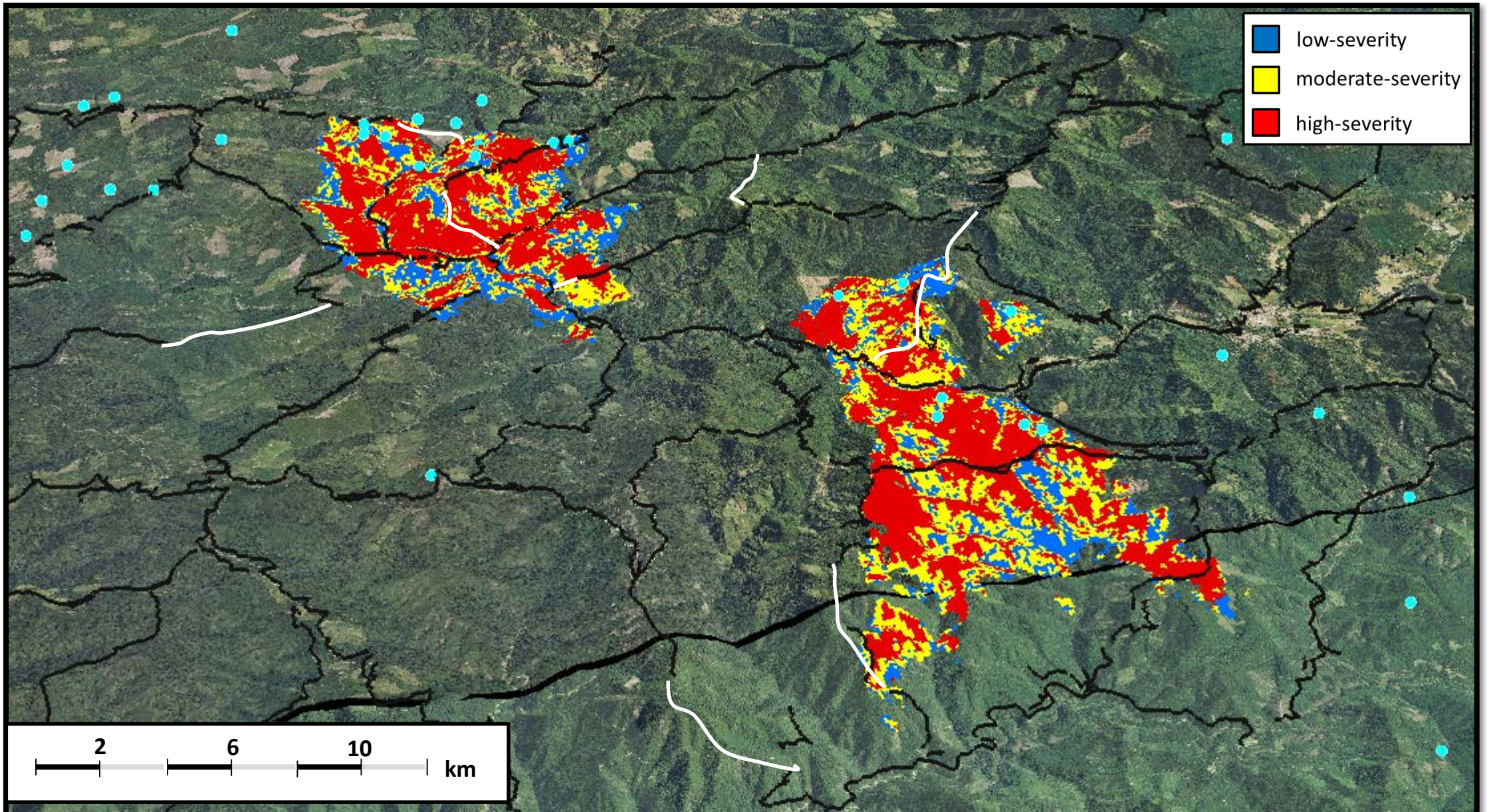
July 27th, 2013

Cumulative area: 11,503 ac



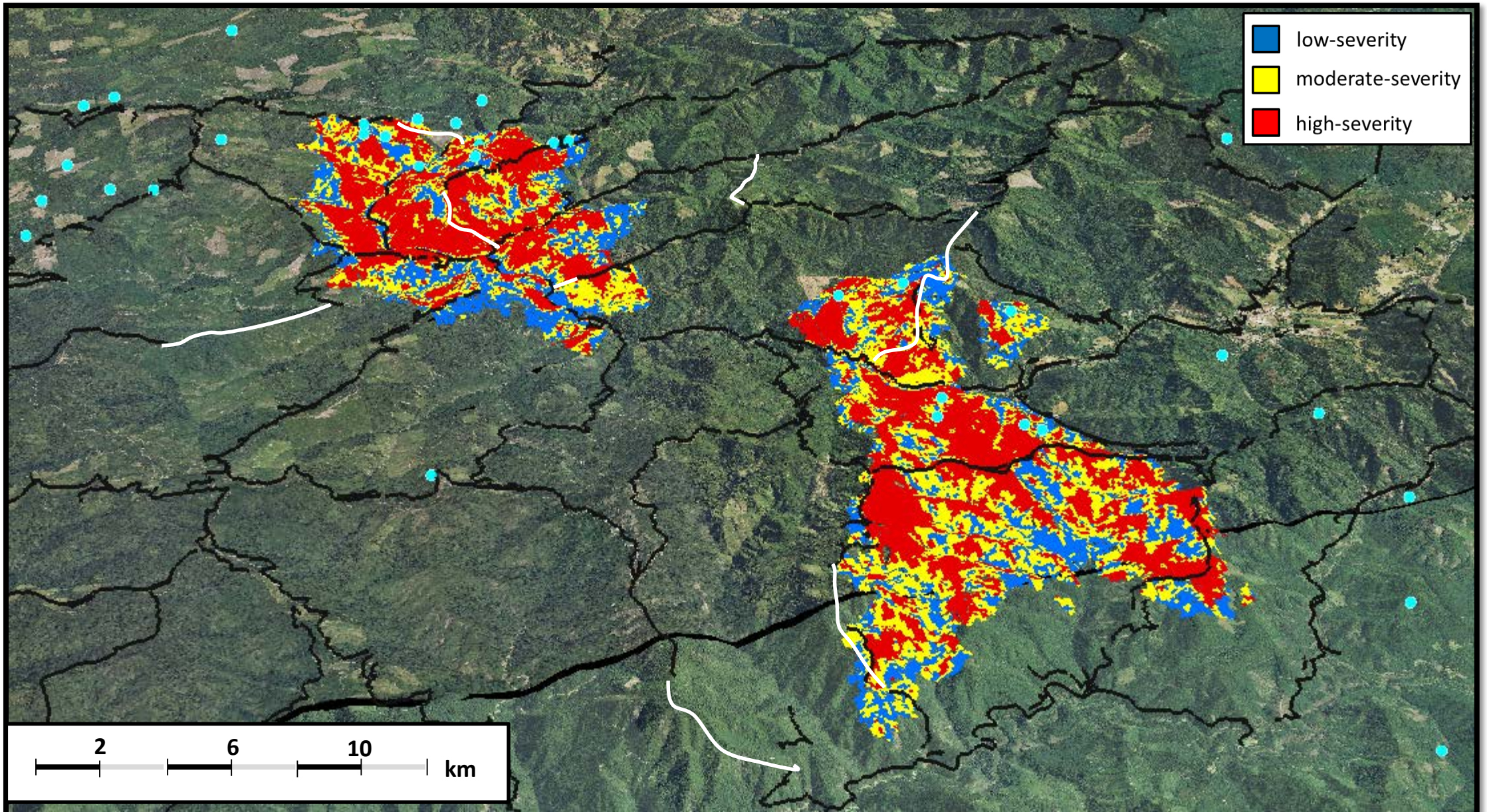
July 28th, 2013

Cumulative area: 21,634 ac



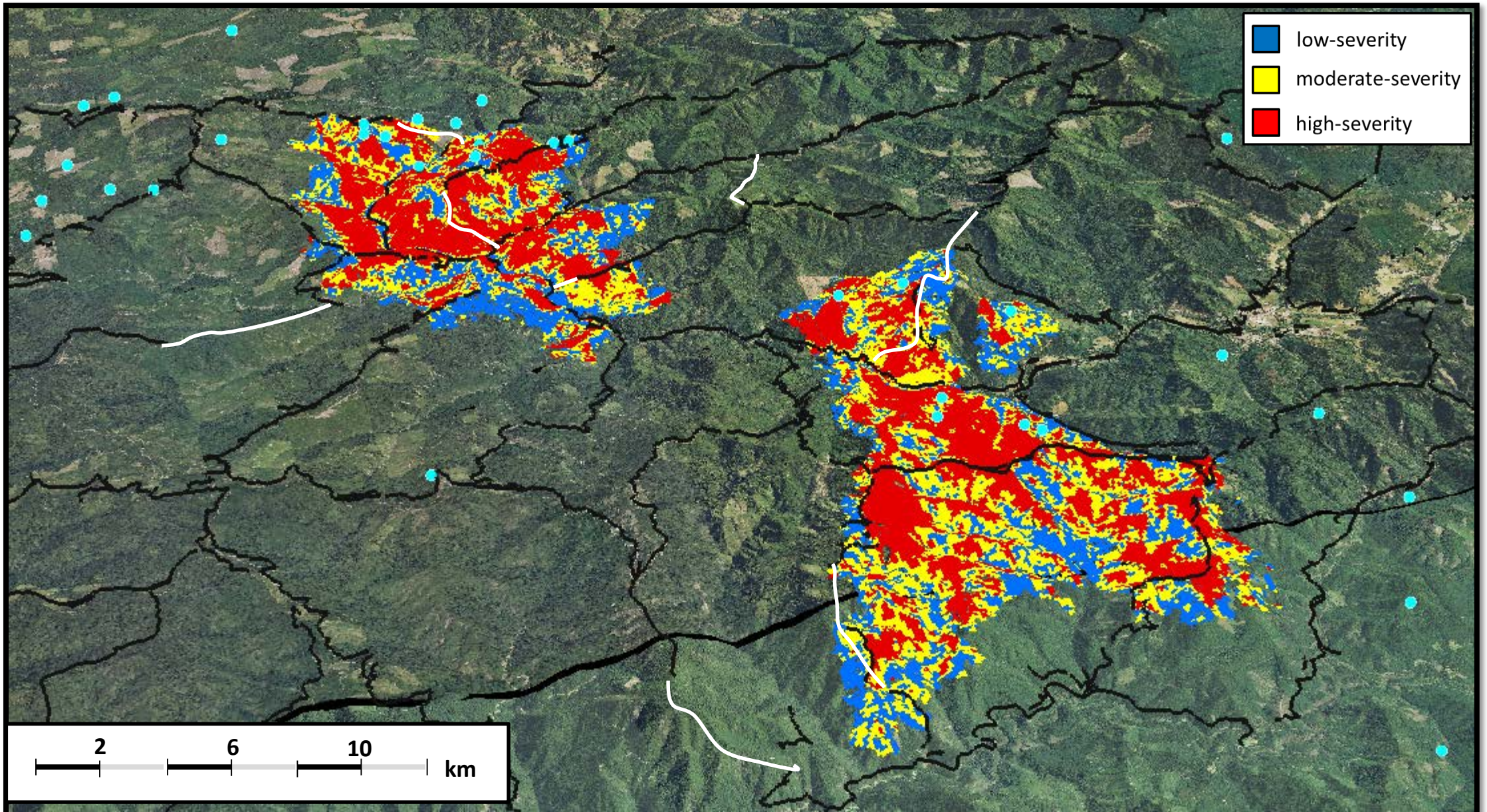
July 29th, 2013

Cumulative area: 25,701 ac



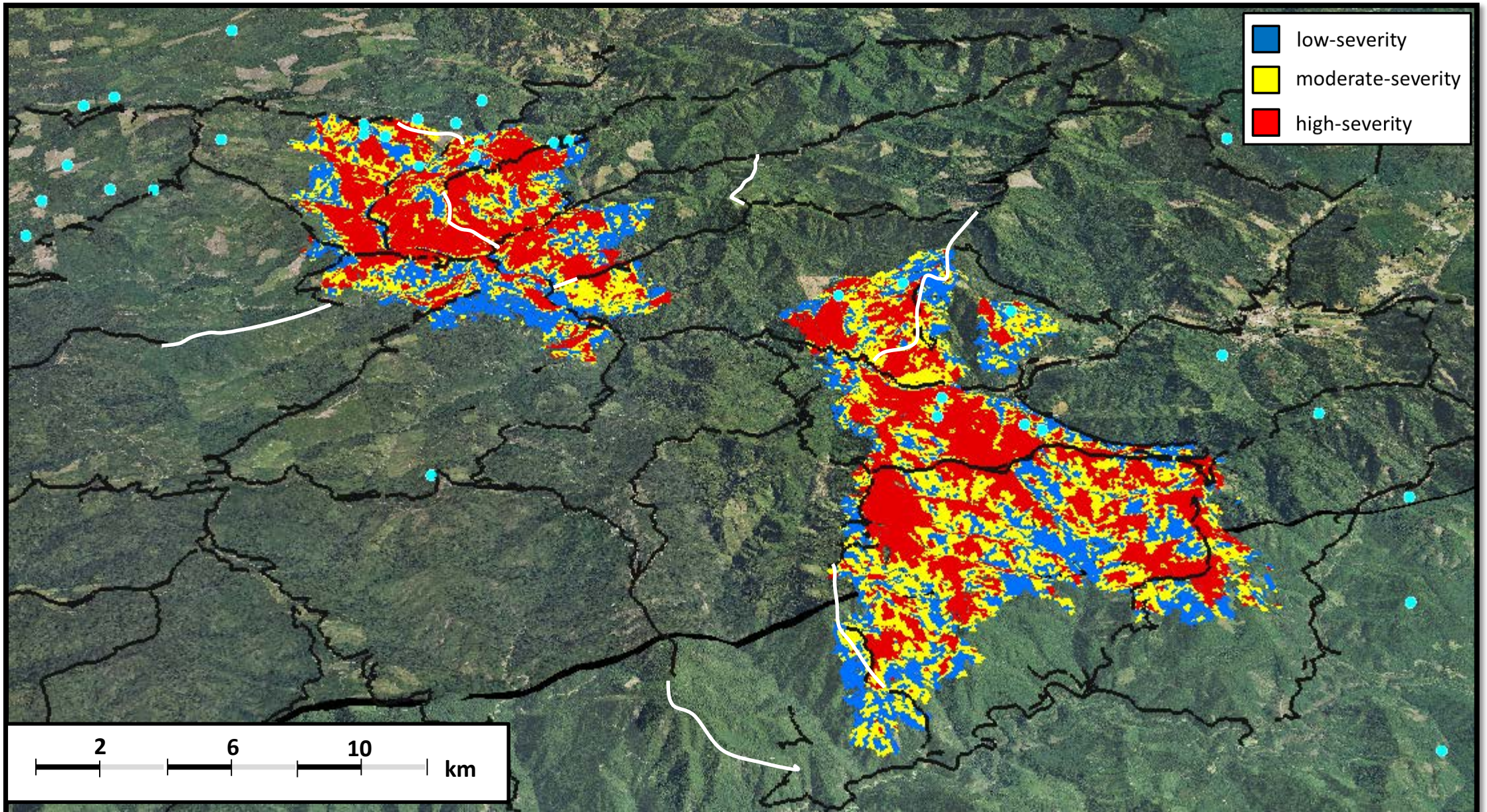
July 29th, 2013

Cumulative area: 28,249 ac



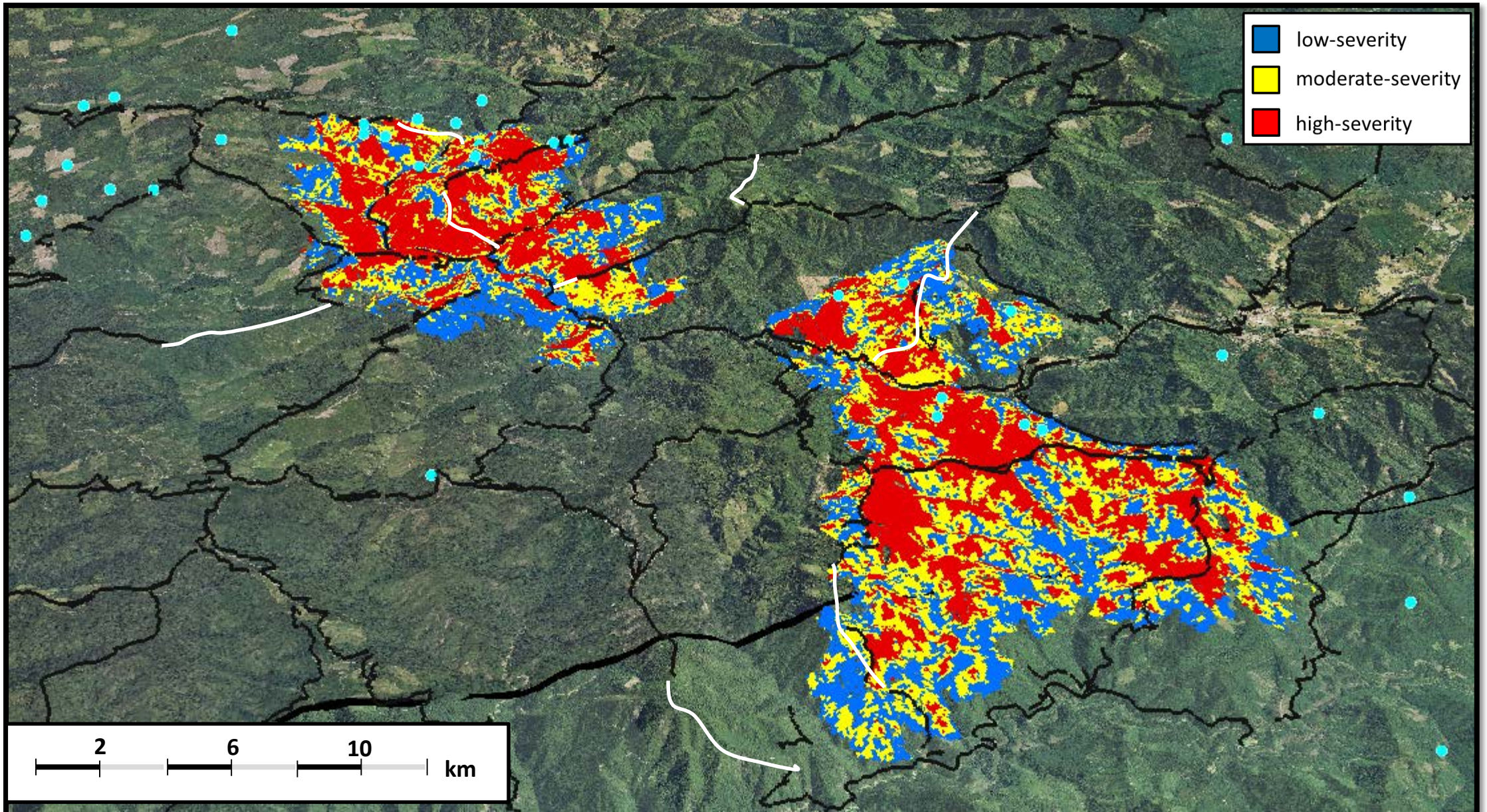
Aug. 1st, 2013

Cumulative area: 28,511 ac



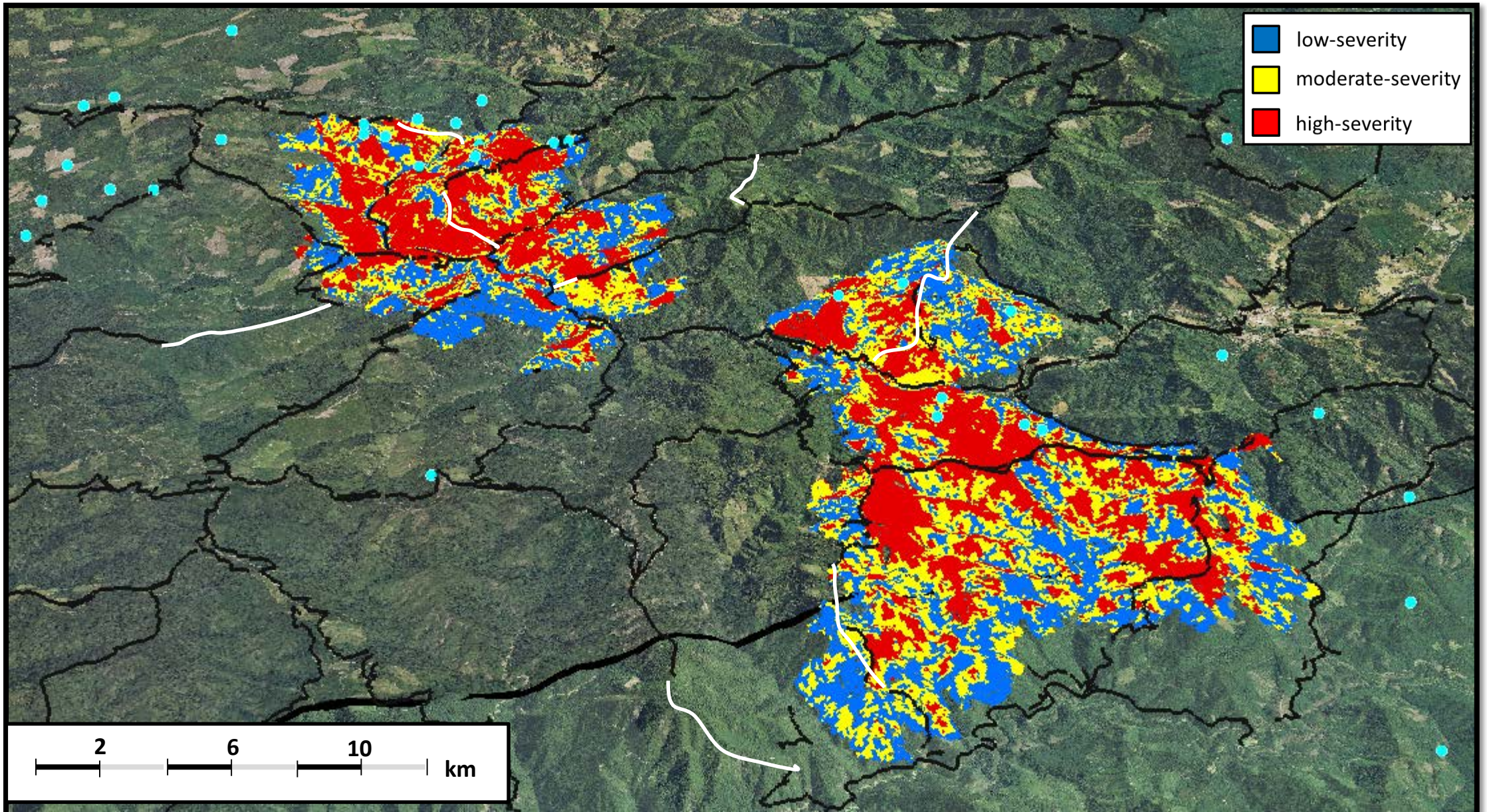
Aug. 2nd, 2013

Cumulative area: 32,274 ac



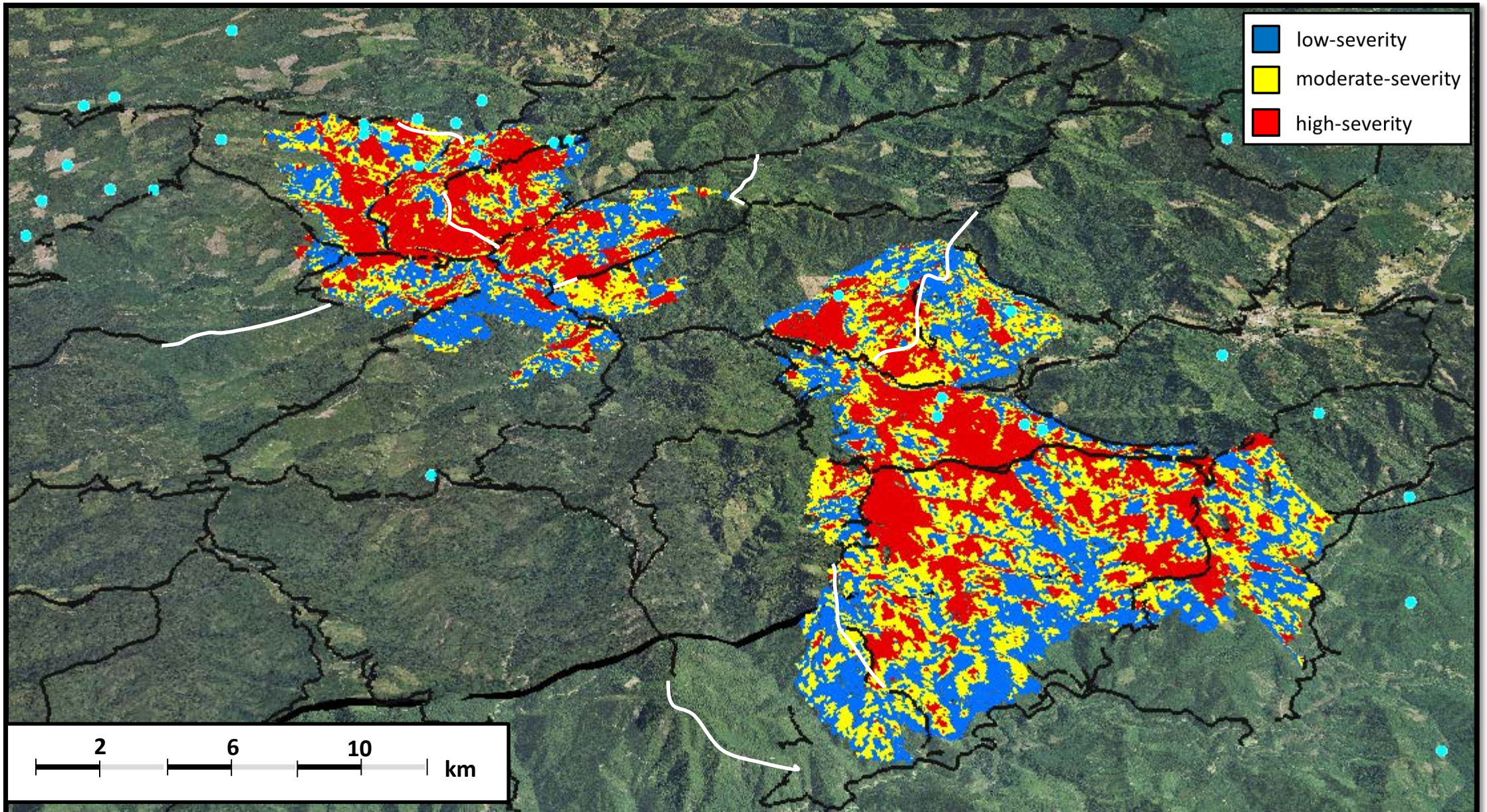
Aug. 3rd, 2013

Cumulative area: 34,147 ac



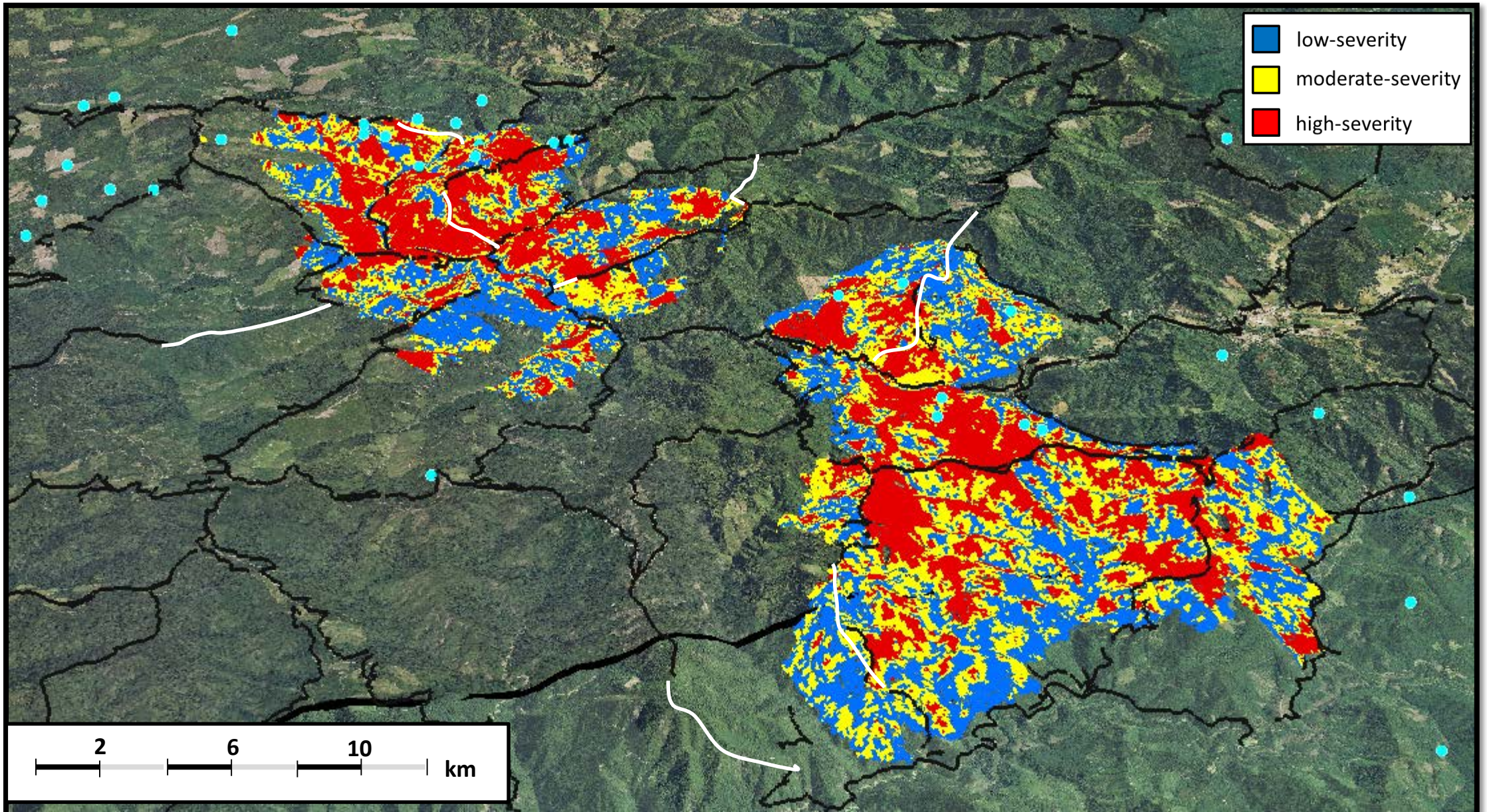
Aug. 4th, 2013

Cumulative area: 36,369 ac



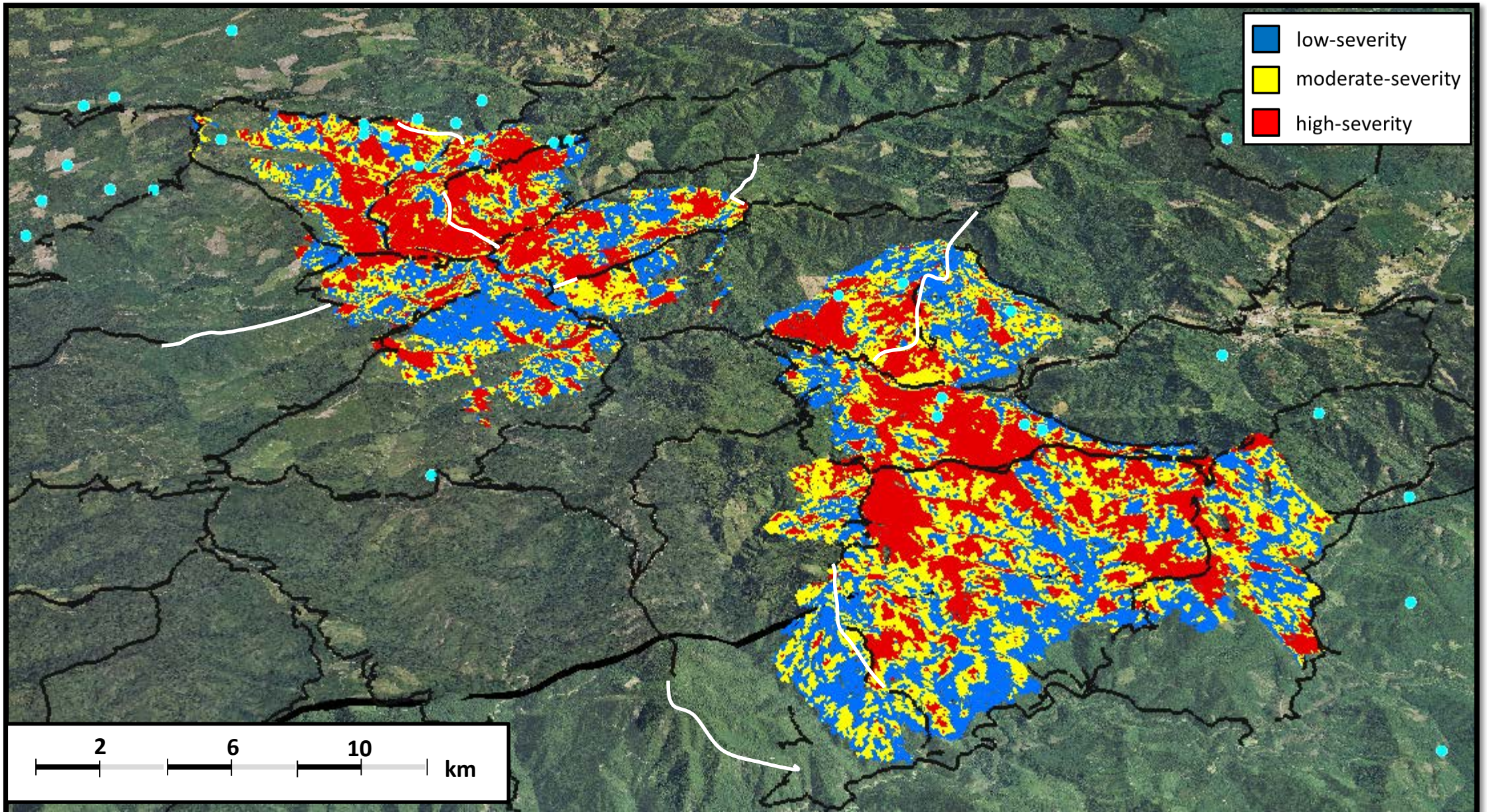
Aug. 5th, 2013

Cumulative area: 38,183 ac



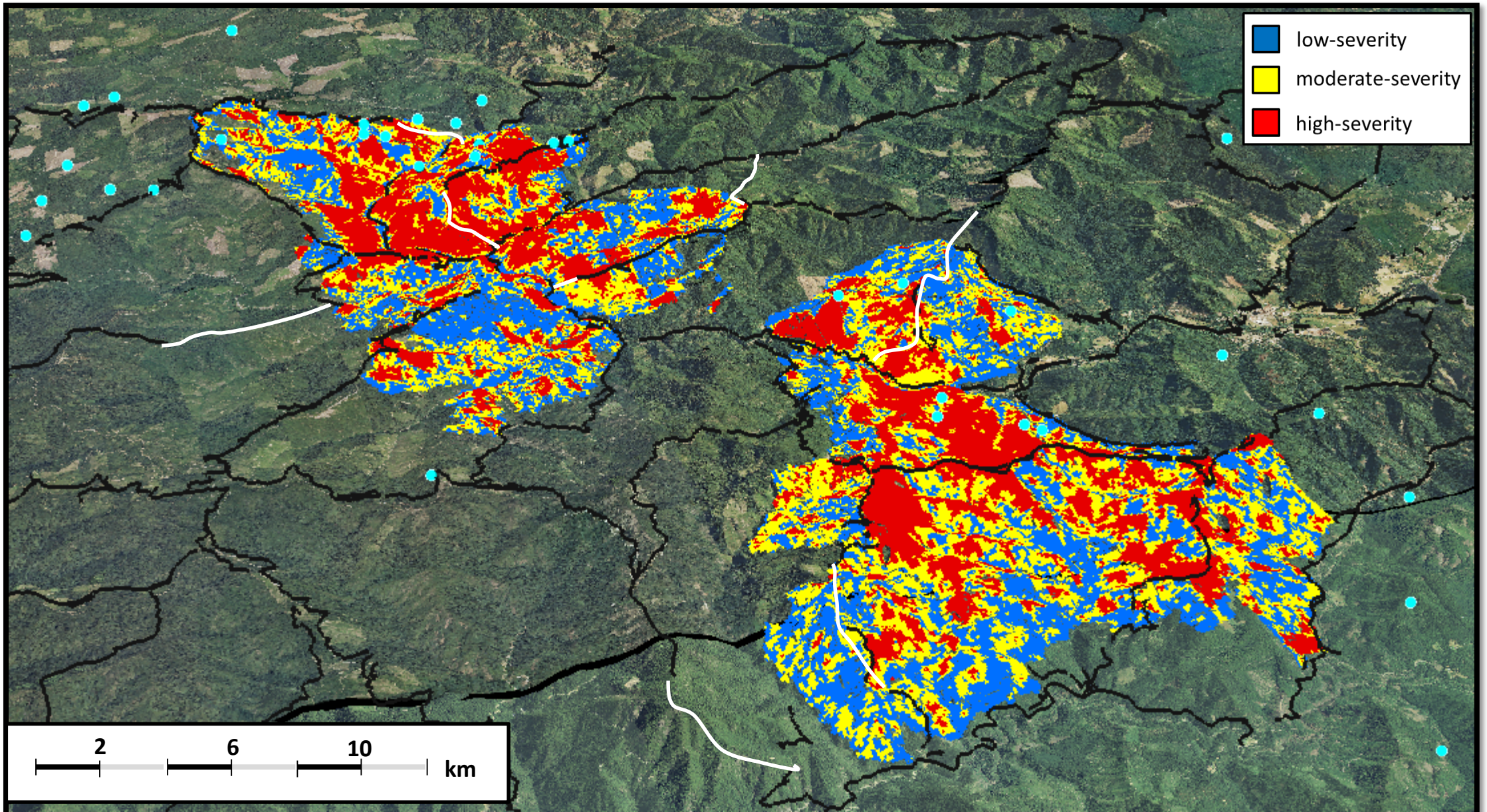
Aug. 6th, 2013

Cumulative area: 40,051 ac



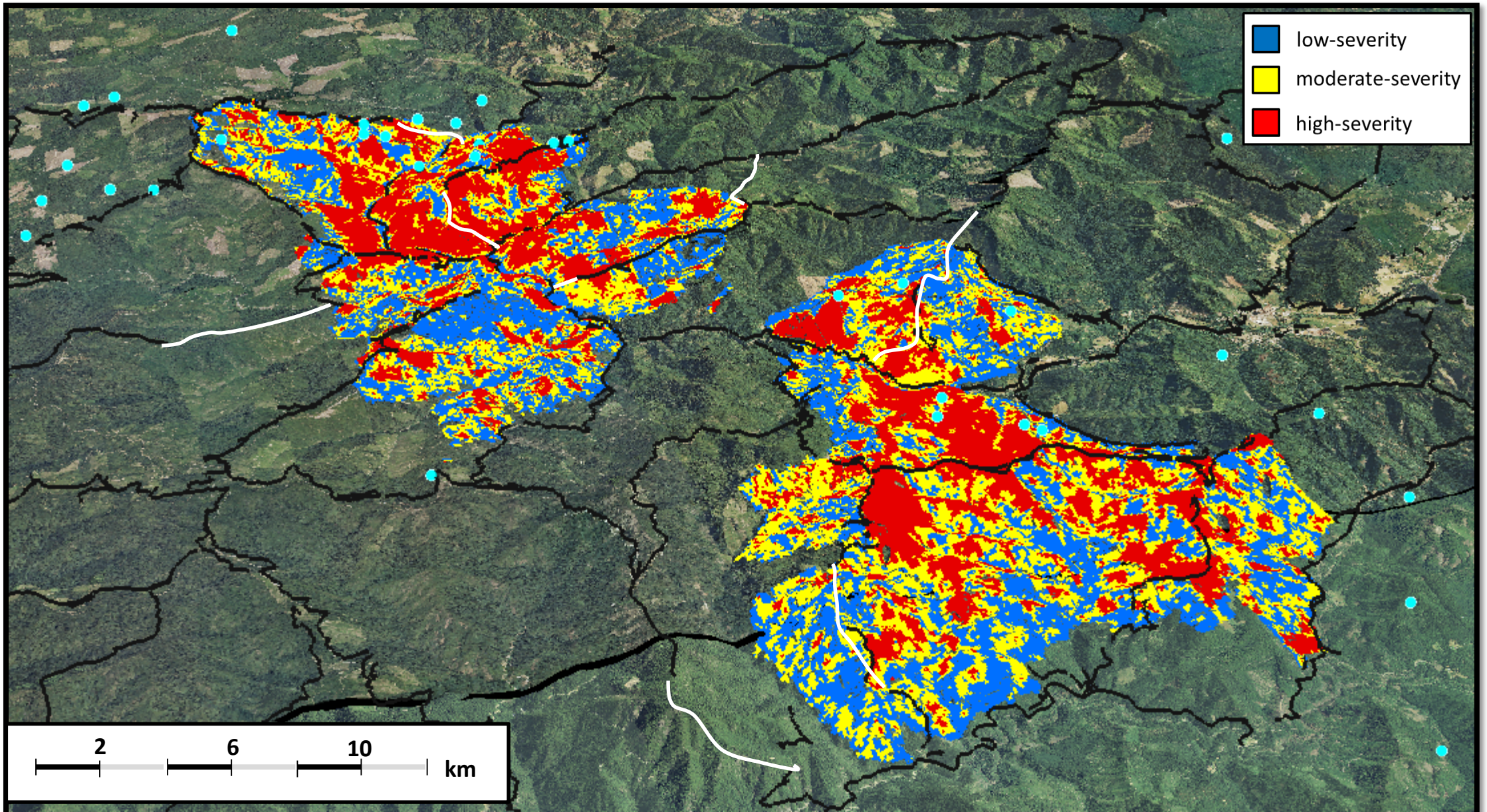
Aug. 7th, 2013

Cumulative area: 42,655 ac



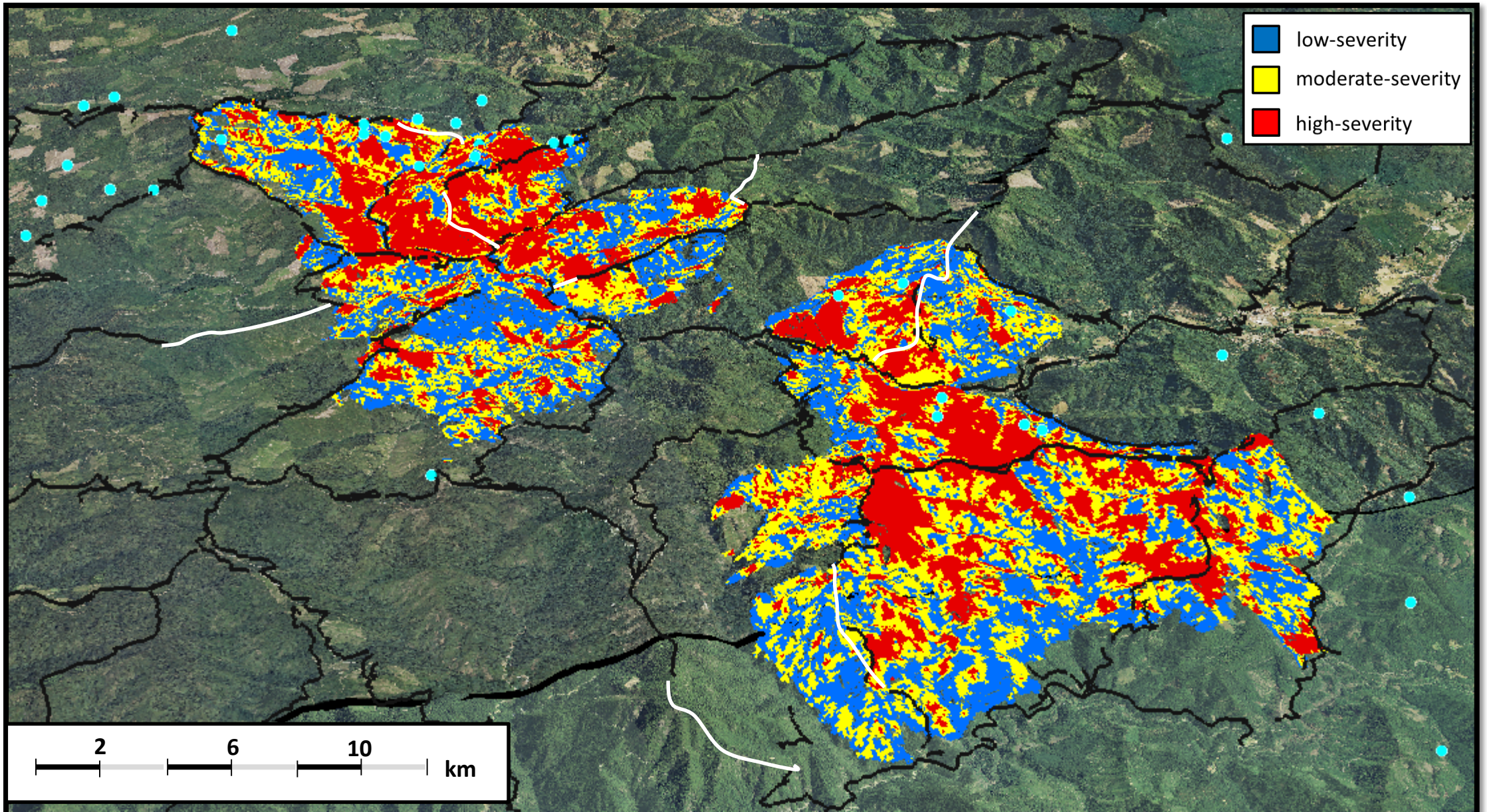
Aug. 8th, 2013

Cumulative area: 44,056 ac



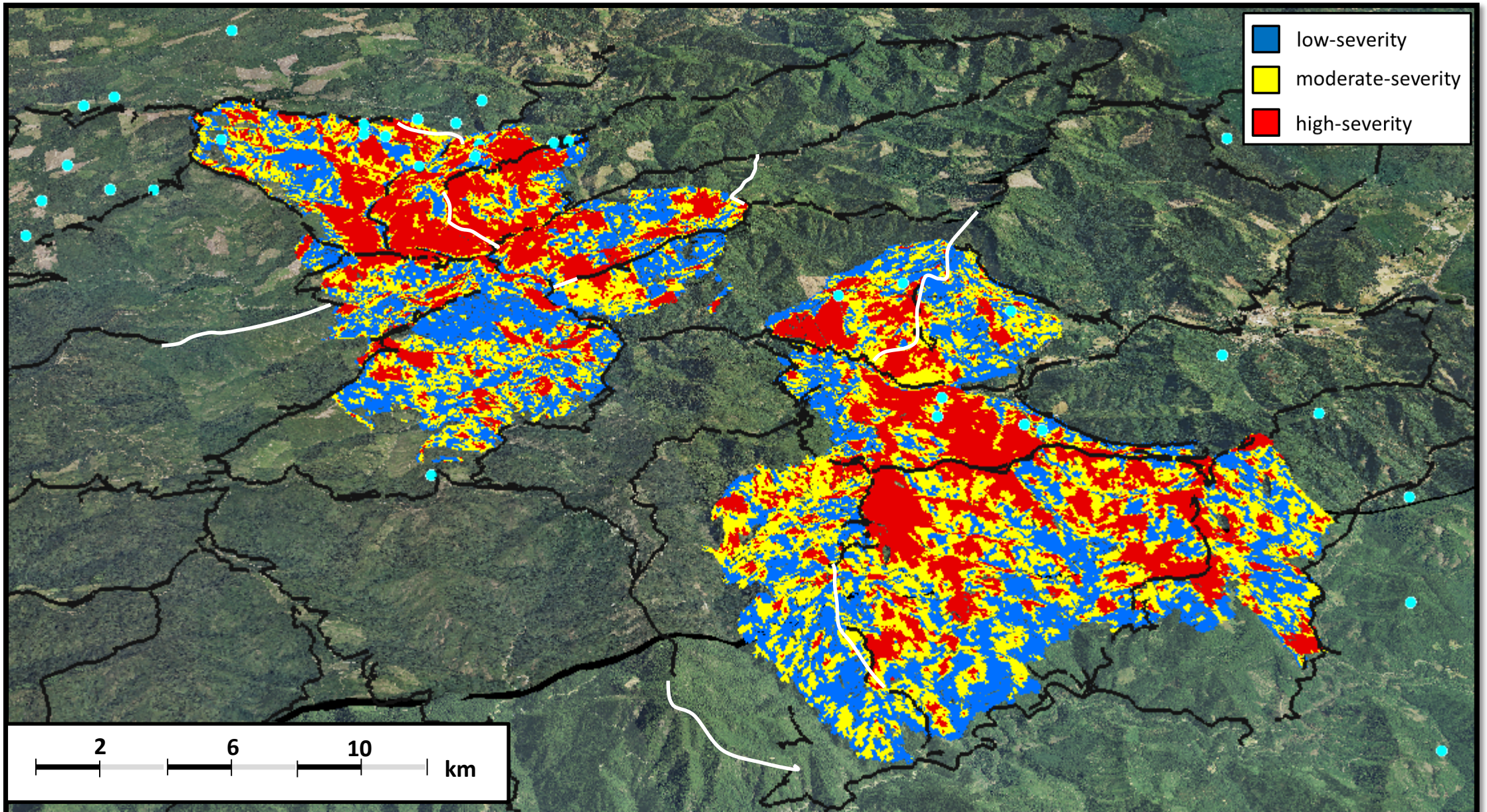
Aug. 9th, 2013

Cumulative area: 44,471 ac



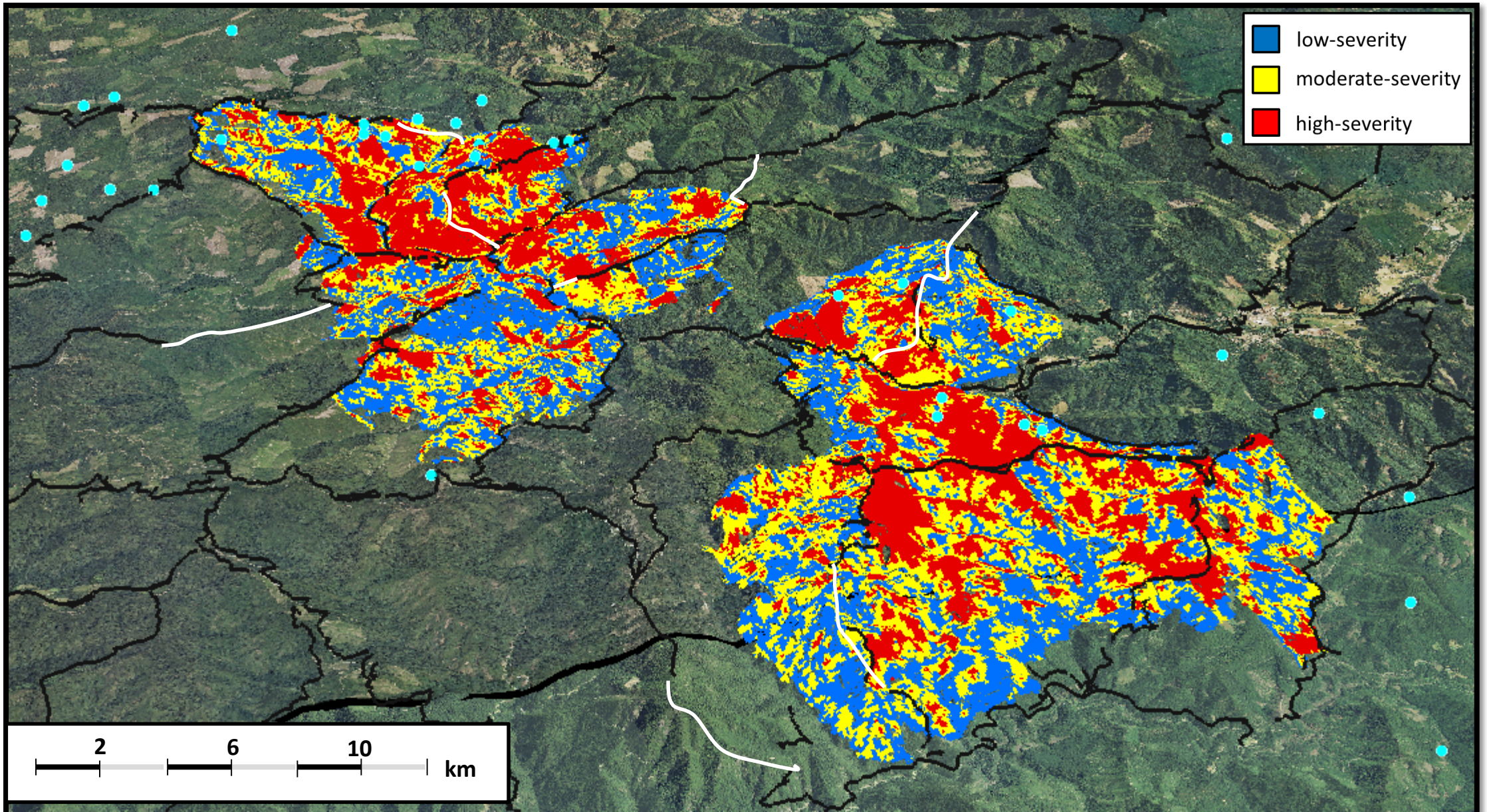
Aug. 10th, 2013

Cumulative area: 45,433 ac



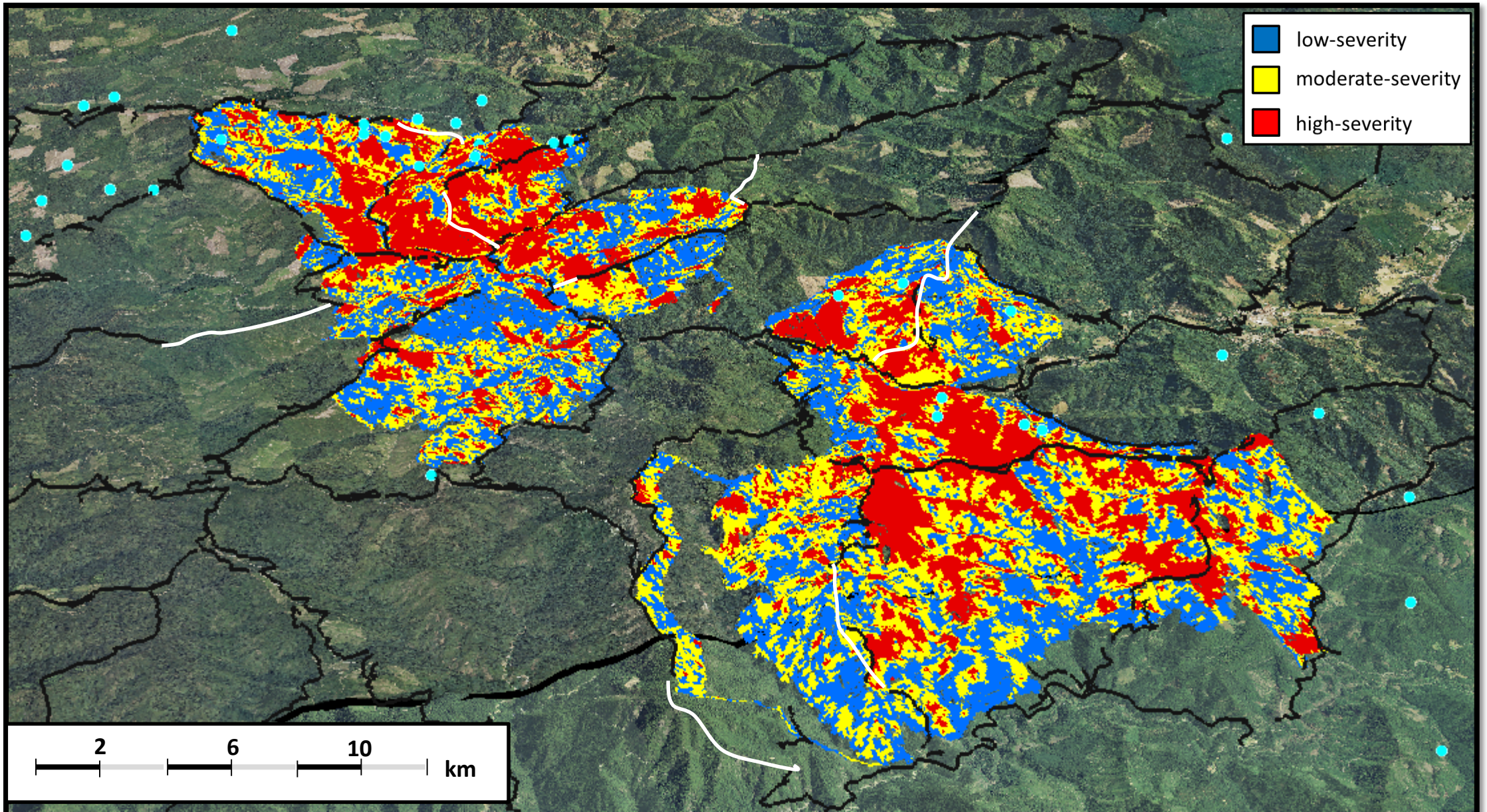
Aug. 12th, 2013

Cumulative area: 45,504 ac



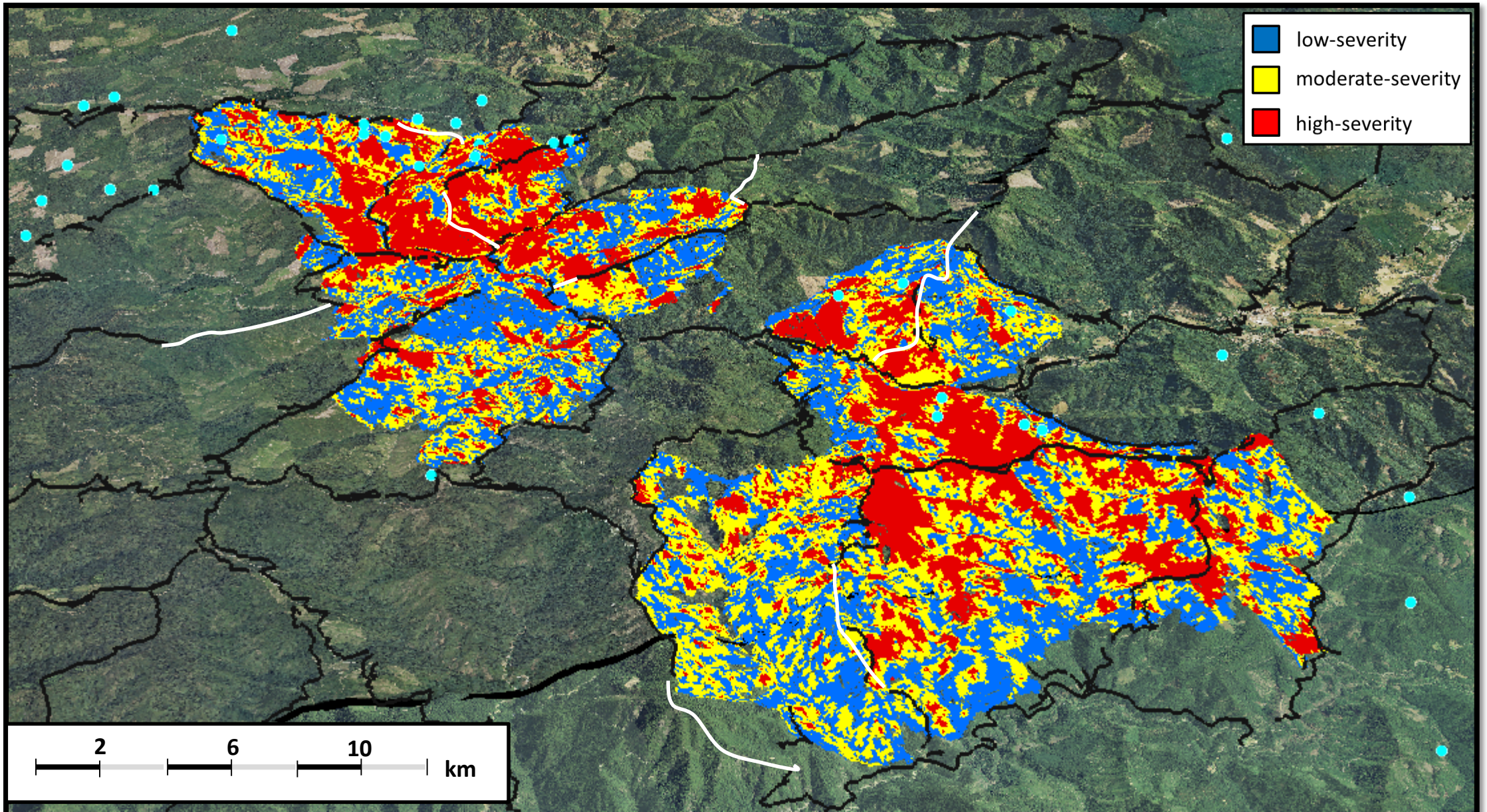
Aug. 15th, 2013

Cumulative area: 46,915 ac



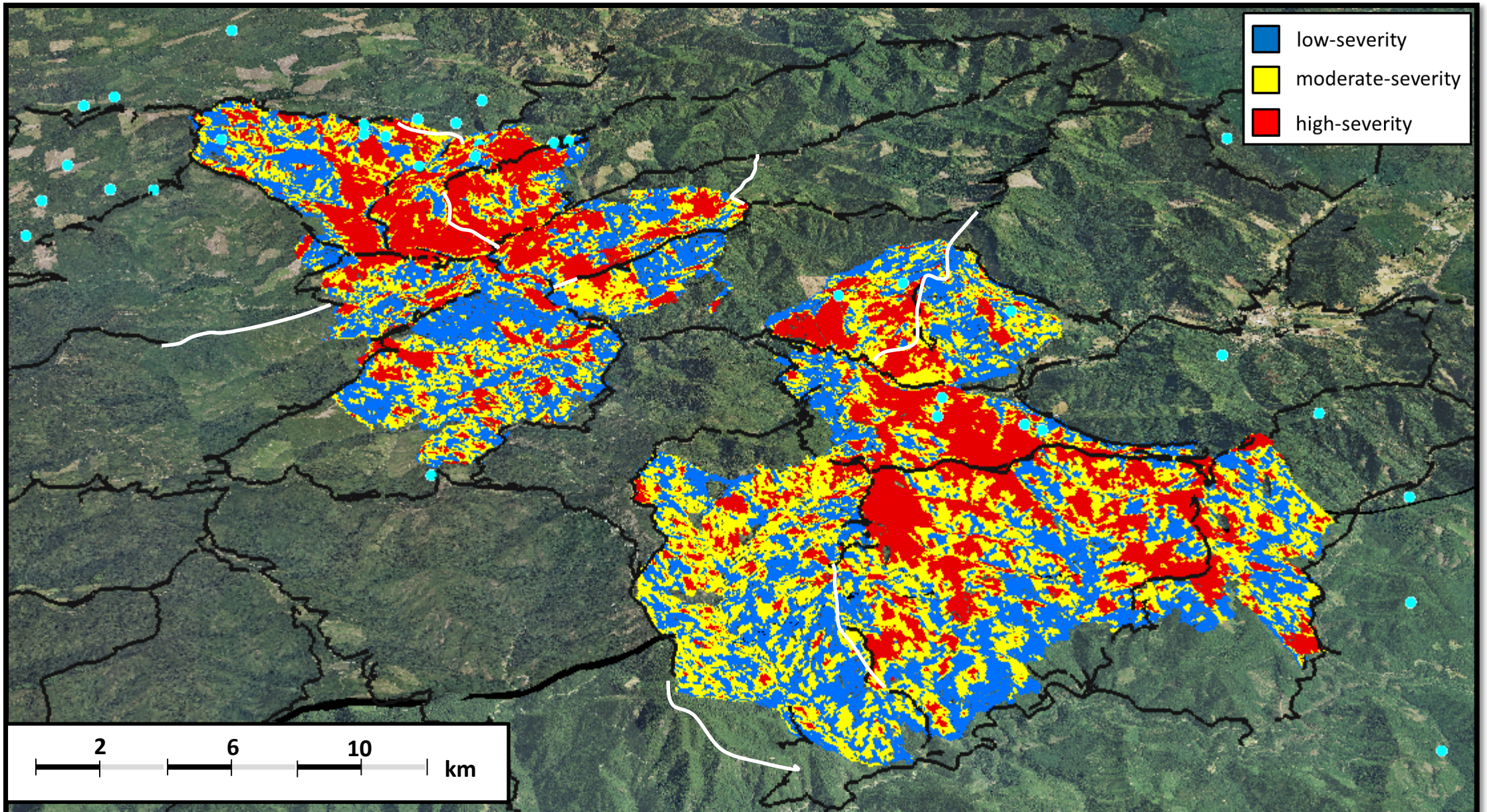
Aug. 18th, 2013

Cumulative area: 48,408 ac



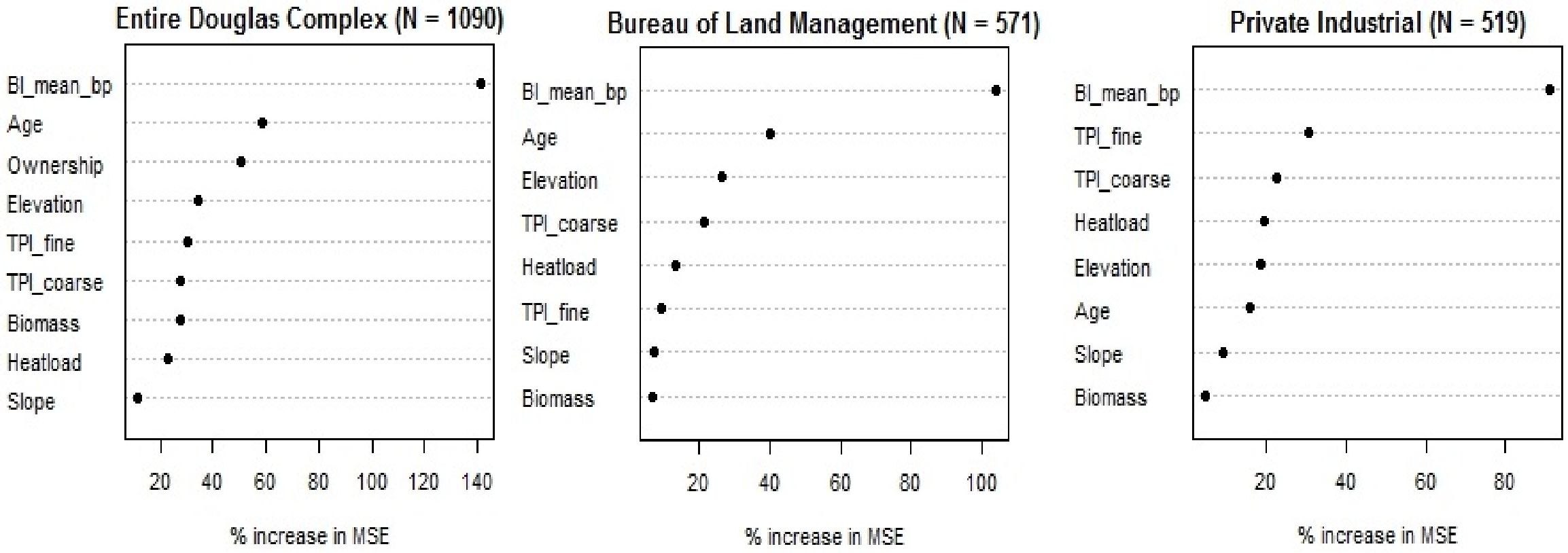
Aug. 20th, 2013

Cumulative area: 48,702 ac

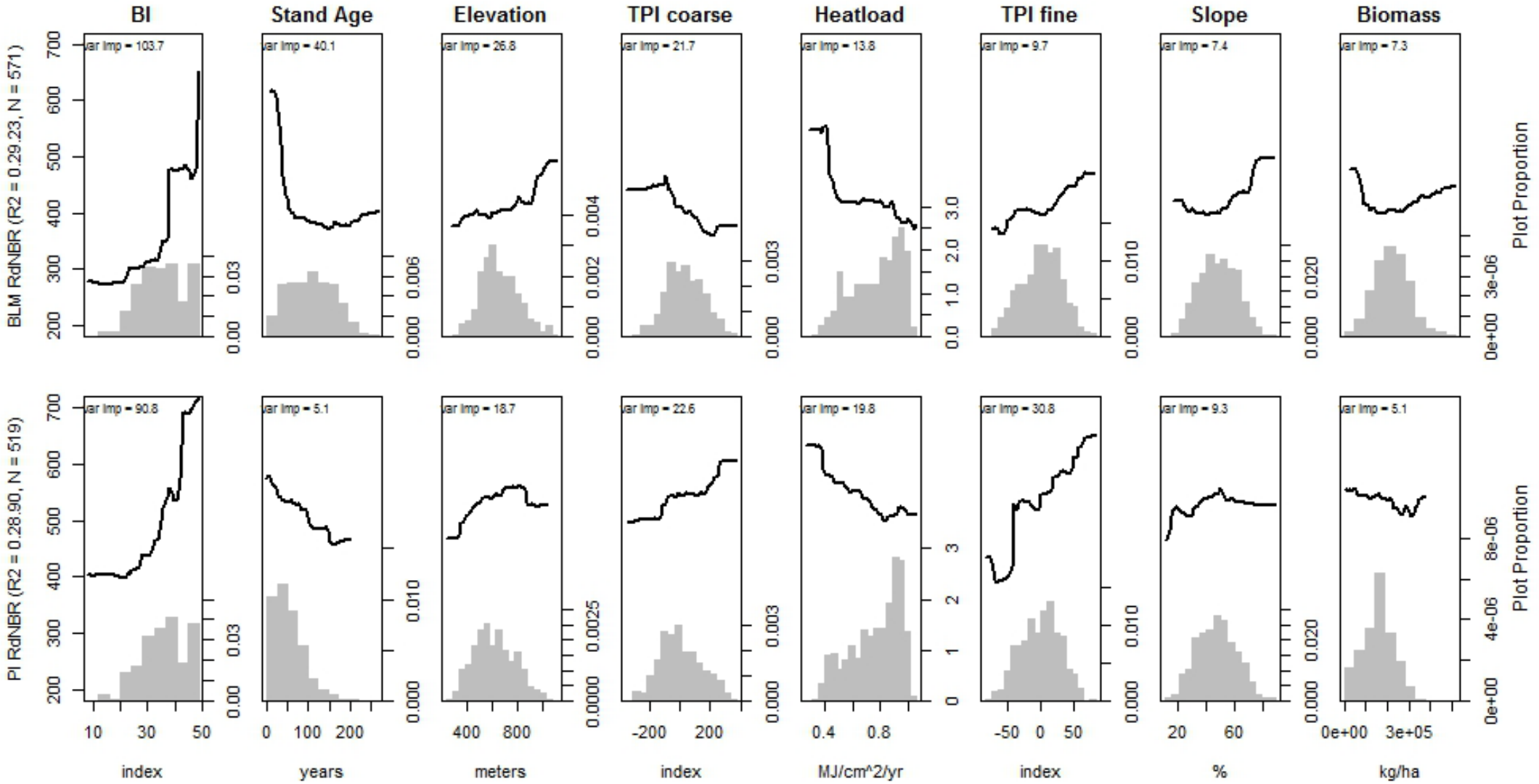


Drivers of fire severity

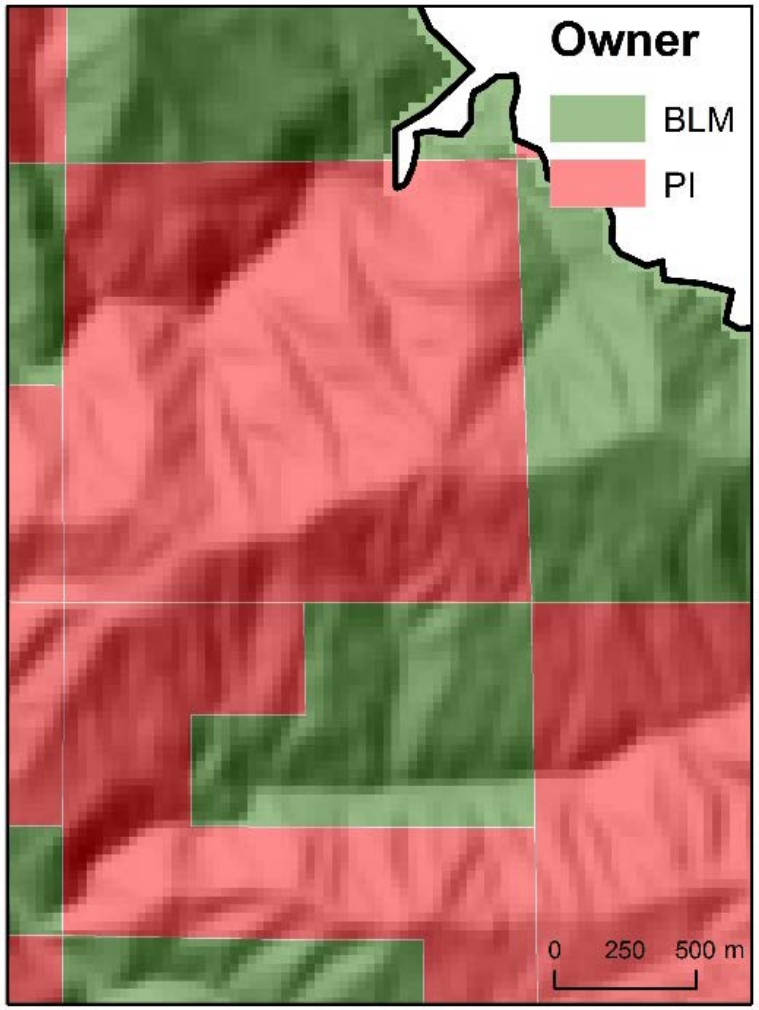
Variable Importance Plots

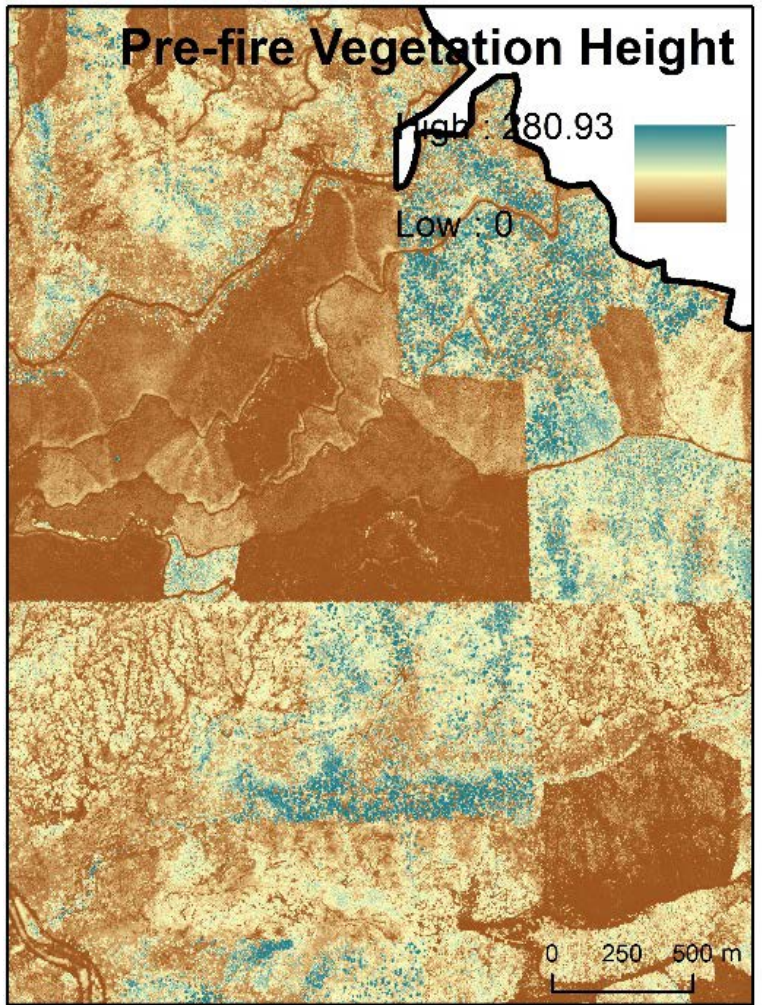


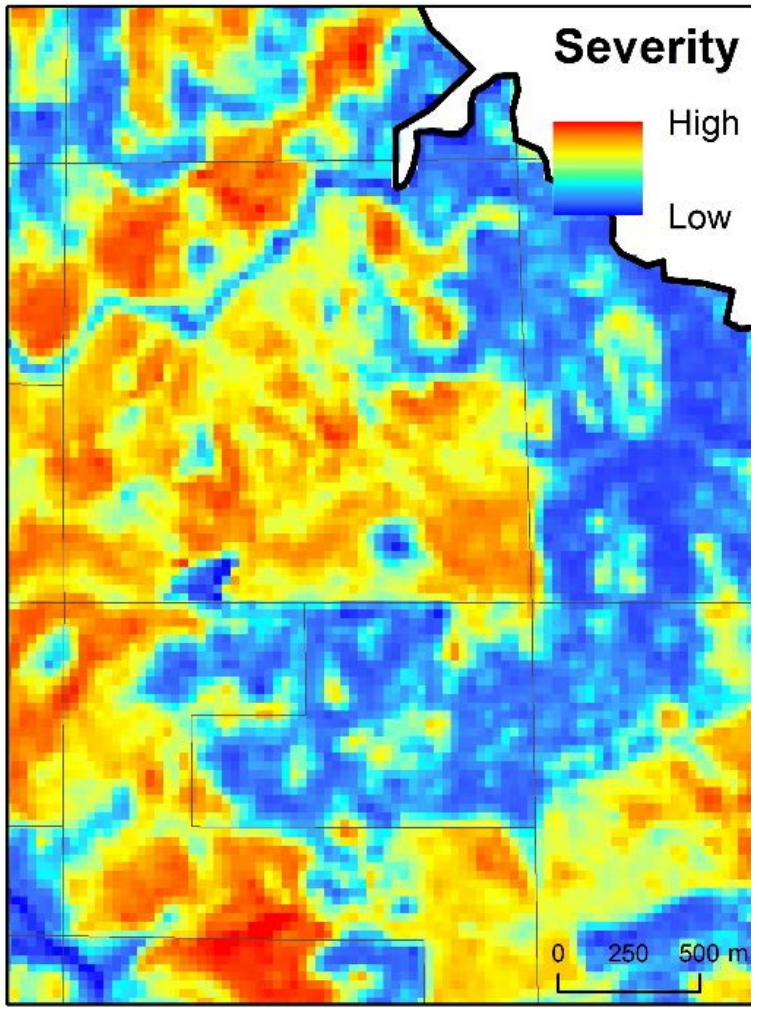
Drivers of fire severity



Contagion – cross-boundary transmission







Conclusions

Ignitions occur across ownerships, solutions may only balance ignition probability

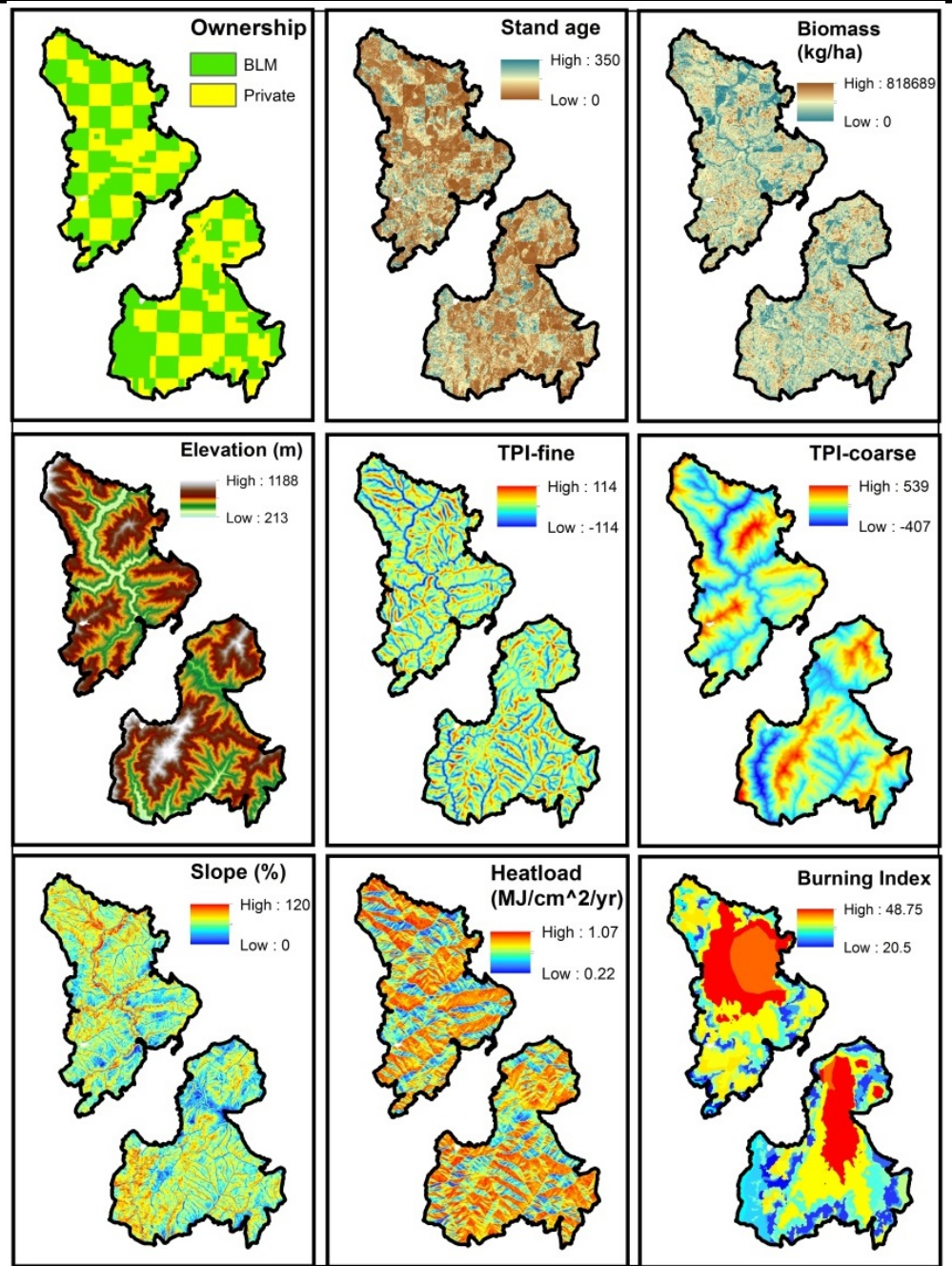
Fire weather the most important driver of fire severity

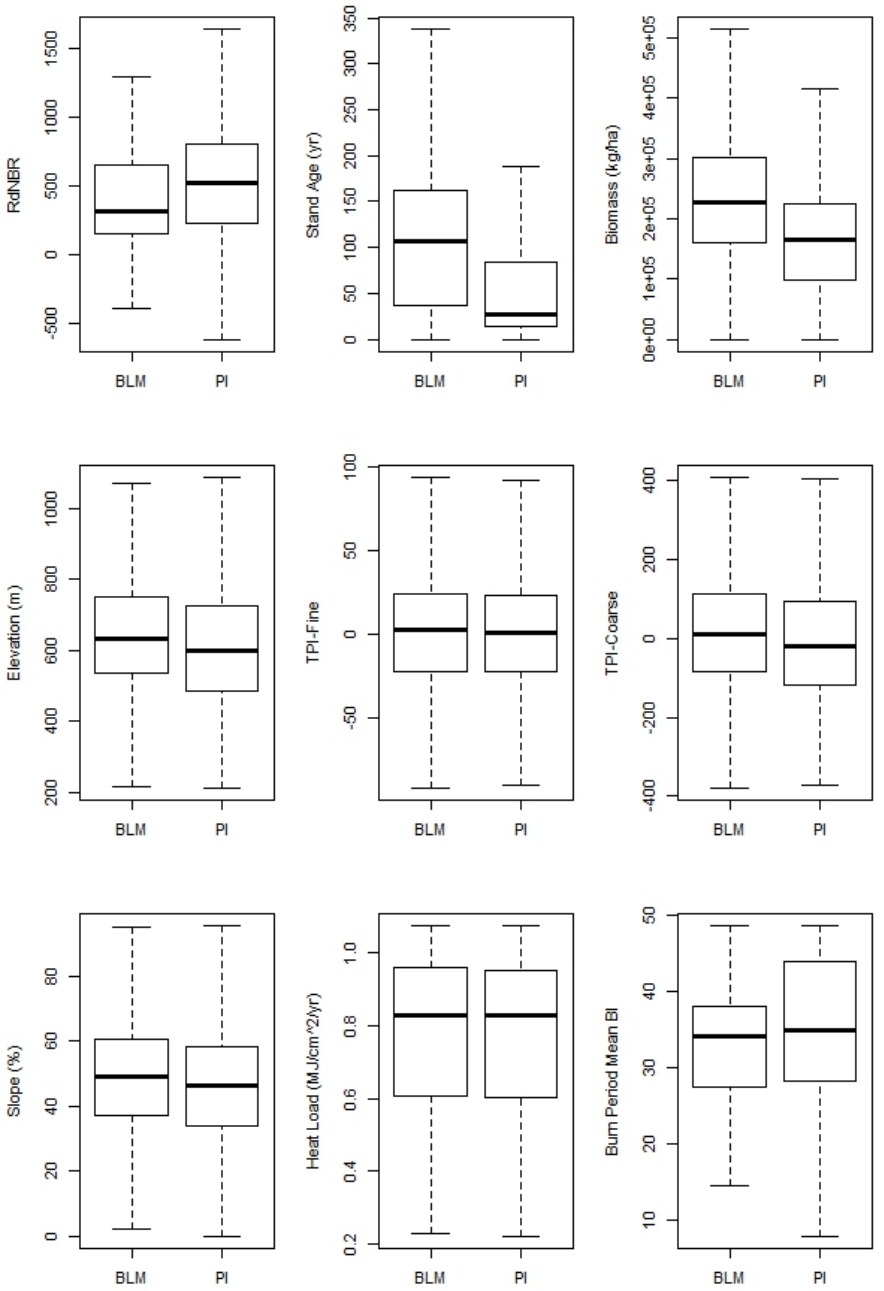
Older forests without treatments on public lands buffer fire effects across landscapes

Transition to timber production will increase landscape-level severity

Spatial pattern of fuels or forest structure, rather than absolute fuel loads, may drive severity response

Questions?


Ownership
BLM
Private
Stand age
High : 350
Low : 0
Biomass (kg/ha)
High : 818689
Low : 0
Elevation (m)
High : 1188
Low : 213
TPI-fine
High : 114
Low : -114
TPI-coarse
High : 539
Low : -407
Slope (%)
High : 120
Low : 0
Heatload (MJ/cm^2/yr)
High : 1.07
Low : 0.22
Burning Index
High : 48.75
Low : 20.5


RdNBR
Stand Age (yr)
Biomass (kg/ha)
Elevation (m)
TPI-Fine
TPI-Coarse
Slope (%)
Heat Load (MJ/cm^2/yr)
Burn Period Mean BI
BLM
PI

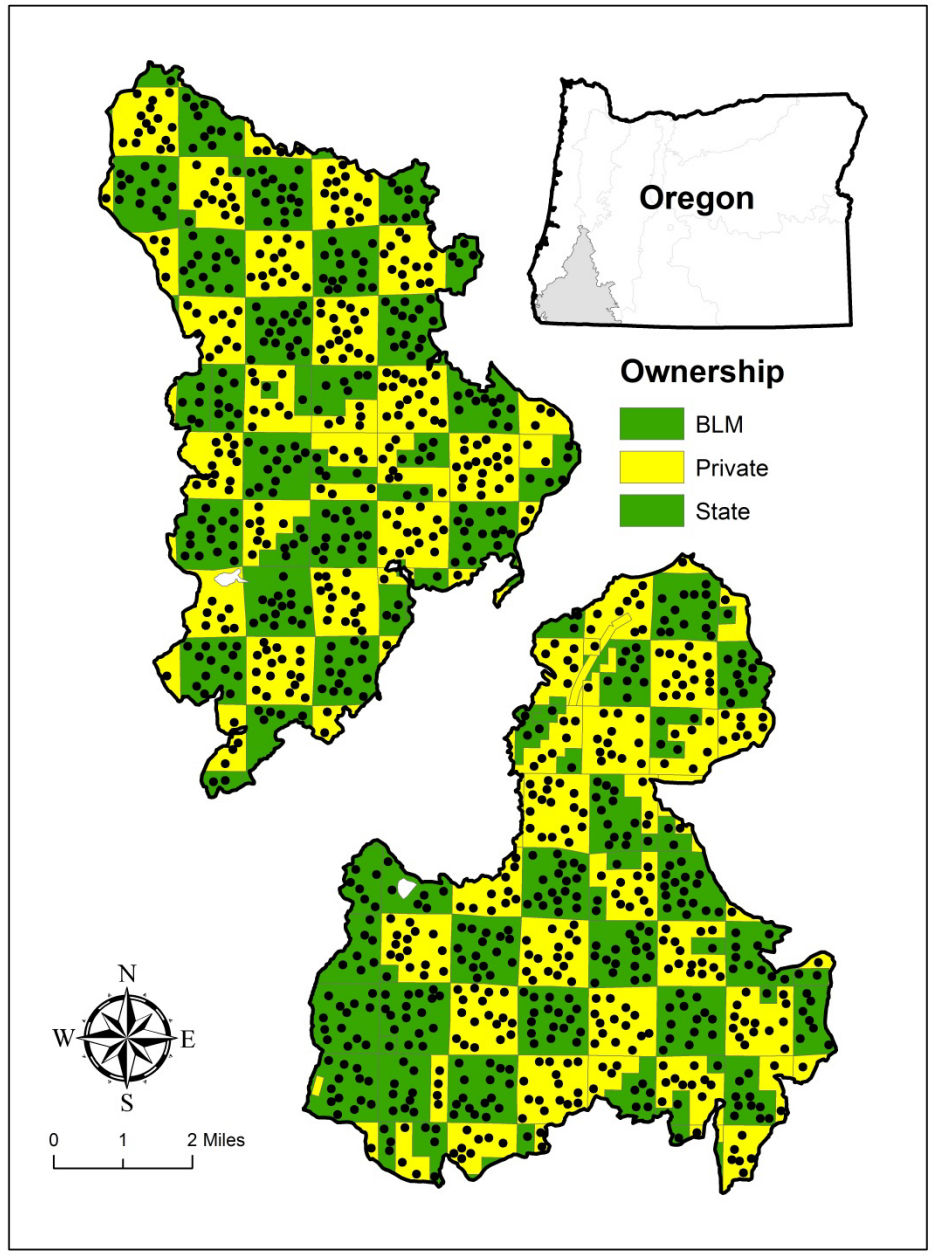
Statistical Methods

Random Forest (RF)

- Variable importance plots
- Partial dependency plots
- Sampled: 200 m inter-plot
- n= 571 BLM, 519 Private

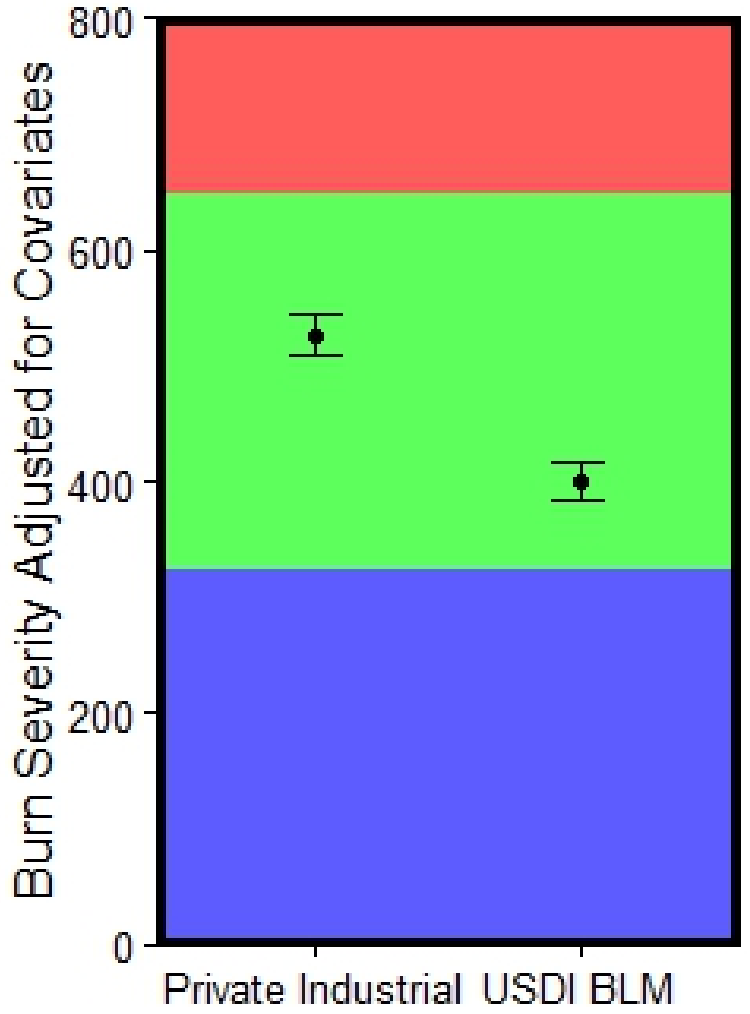
Generalized Least Squares (GLS)

- Sample same as RF
- Spherical exponential correlation structure accounts for spatial autocorrelation
- Formal model selection (stepwise with AIC)
- Fixed effects of explanatory variables



Results: Generalized Linear Model

Variable	Estimate	Standard Error	t Value	P Value
(Intercept)	99.1015	84.0105	1.1796	0.2384
Age	-0.8944	0.1622	-5.5138	0.0000
BI_mean_bp	10.6097	1.1373	9.3291	0.0000
Ownership	75.6307	21.7421	3.4785	0.0005
Elevation	0.1444	0.0828	1.7428	0.0817
TPI_fine	1.2543	0.2462	5.0956	0.0000
Heatload	-149.5337	39.4539	-3.7901	0.0002
Slope	1.1887	0.5909	2.0115	0.0445



Conclusions

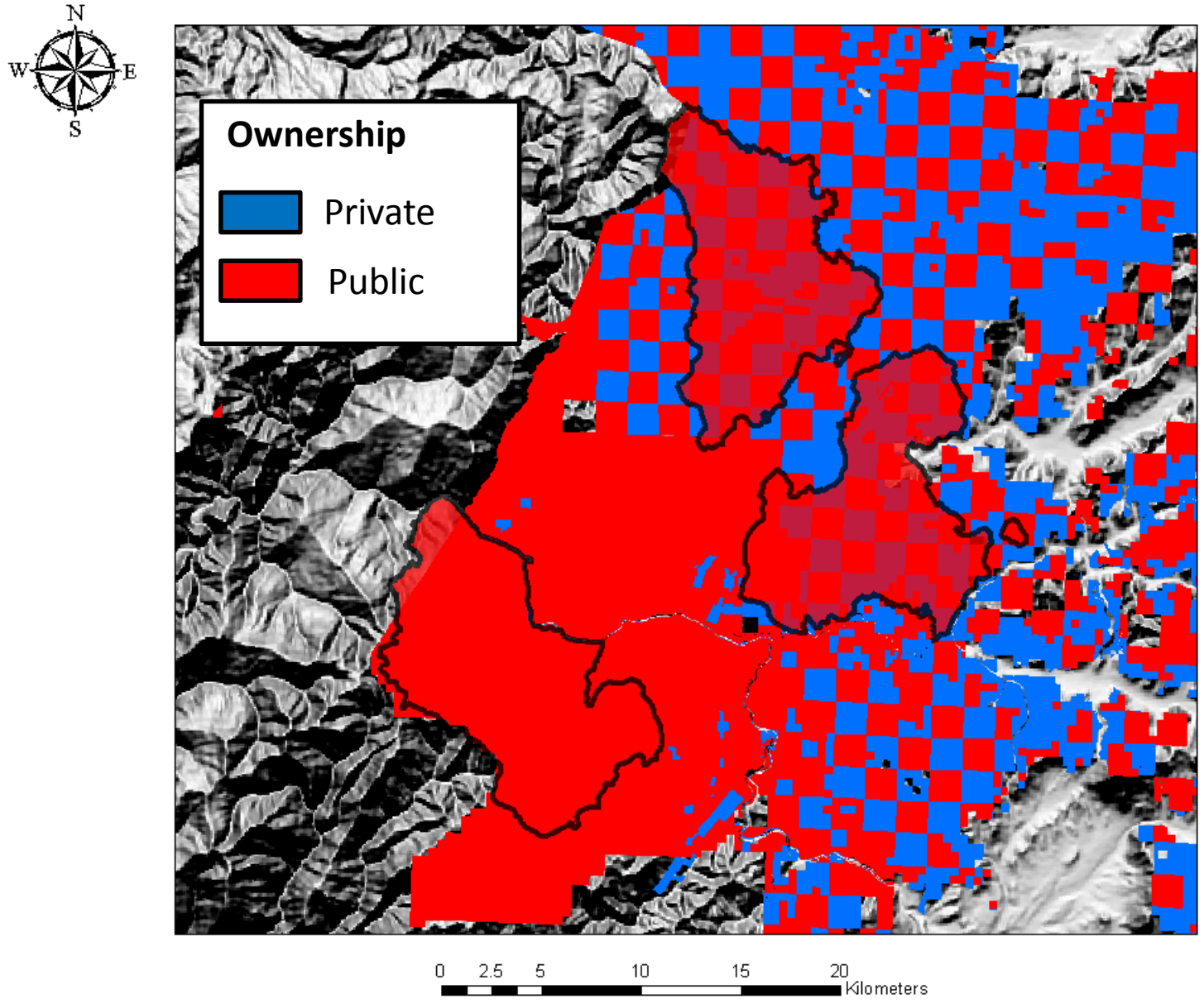
"All hands, all lands" approach means private industrial forestry may need to change their management regimes

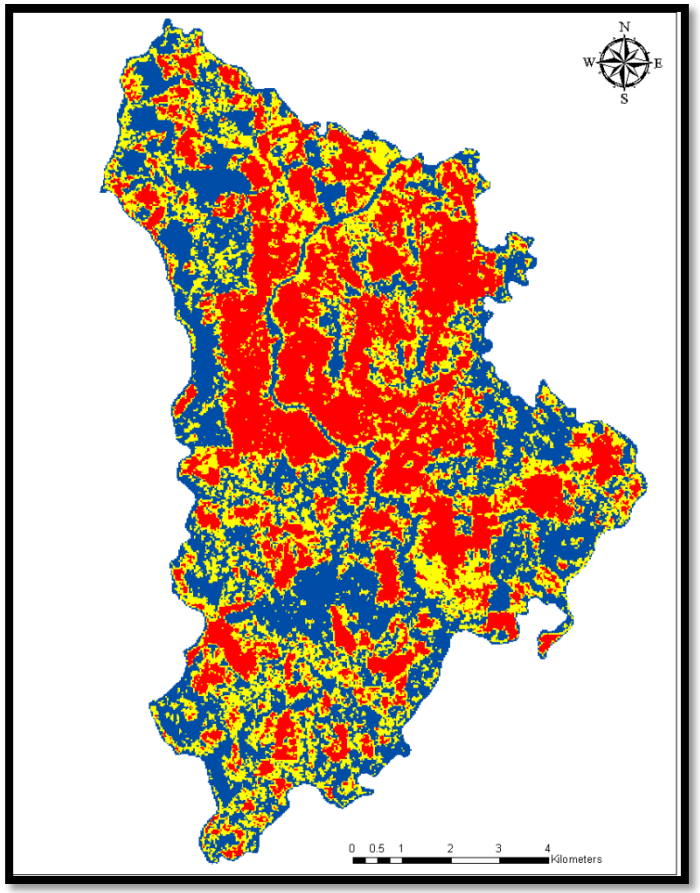
Fire-prone landscapes would benefit by defragmentation of ownership

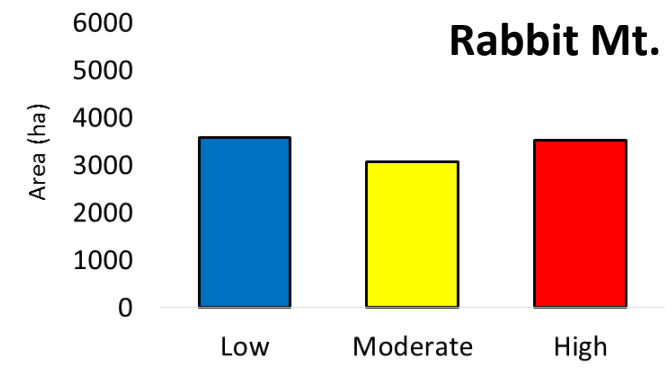
Policies must address private lands management

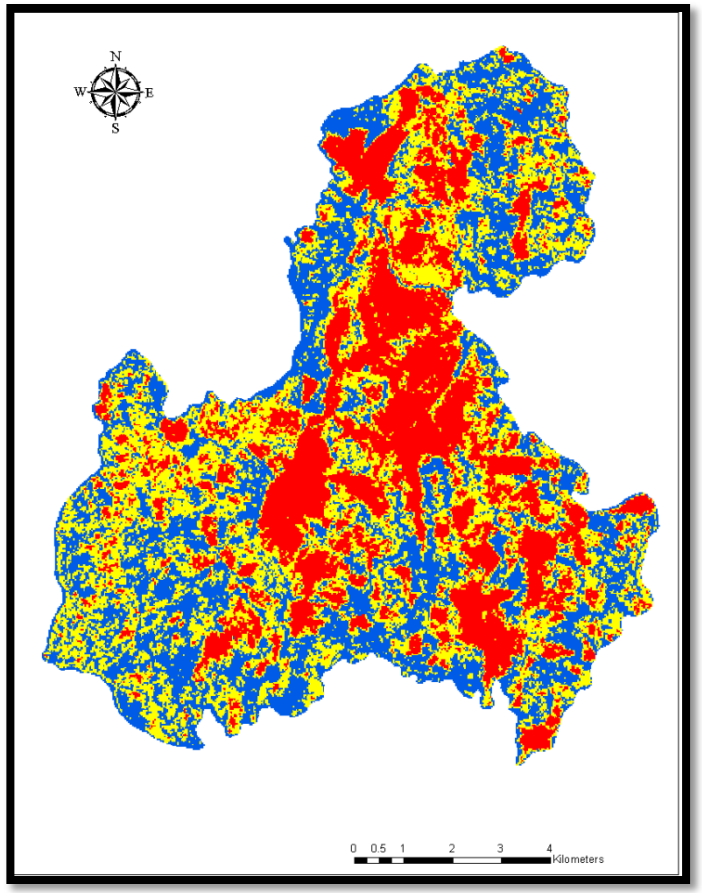
Next steps

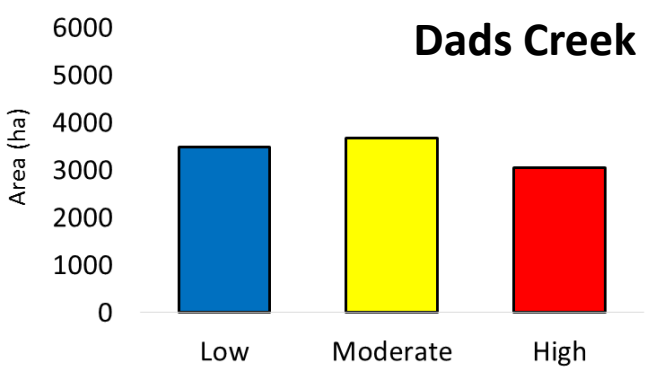
– Variable effects observed in fire on public lands only

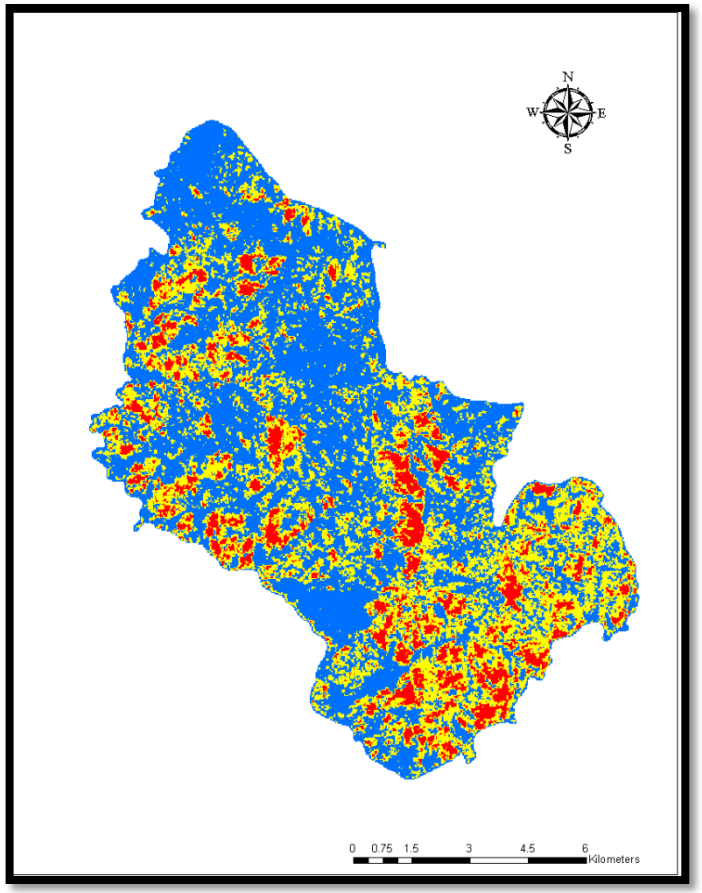



N
W
E
S
0 0.5 1 2 3 4
Kilometers


Rabbit Mt.
Area (ha)
6000
5000
4000
3000
2000
1000
0
Low
Moderate
High


N
W
E
S
0 0.5 1 2 3 4
Kilometers


Dads Creek
Area (ha)
6000
5000
4000
3000
2000
1000
0
Low
Moderate
High


N
W
E
S
0 0.75 1.5 3 4.5 6
Kilometers


Big Windy
Area (ha)
6000
5000
4000
3000
2000
1000
0
Low
Moderate
High

Acknowledgements

- Krisann Kosel
  - USDI BLM, Roseburg District
- Robert Kennedy
  - Oregon State University, Geosciences
- John Bailey
  - Oregon State University, College of Forestry

Fire in mixed-ownership landscapes

Fuels are the only component of fire behavior triangle forest managers can alter

Traditional Paradigm:

- *Fire suppressed, unthinned, older forests have greater fuel accumulation and connectivity, resulting in higher fire severity*

- *Implies younger managed forests will have lower fire severity*

Summary - Ignitions

- More ignitions on private lands when scaled by land base, but majority are human caused
- More lightning ignitions on BLM, probably because of their taller trees and higher abundance of snags
- BLM ignitions more likely to escape IA, probably because multiple ignitions are ignited by lightning storms and this overwhelms suppression resources

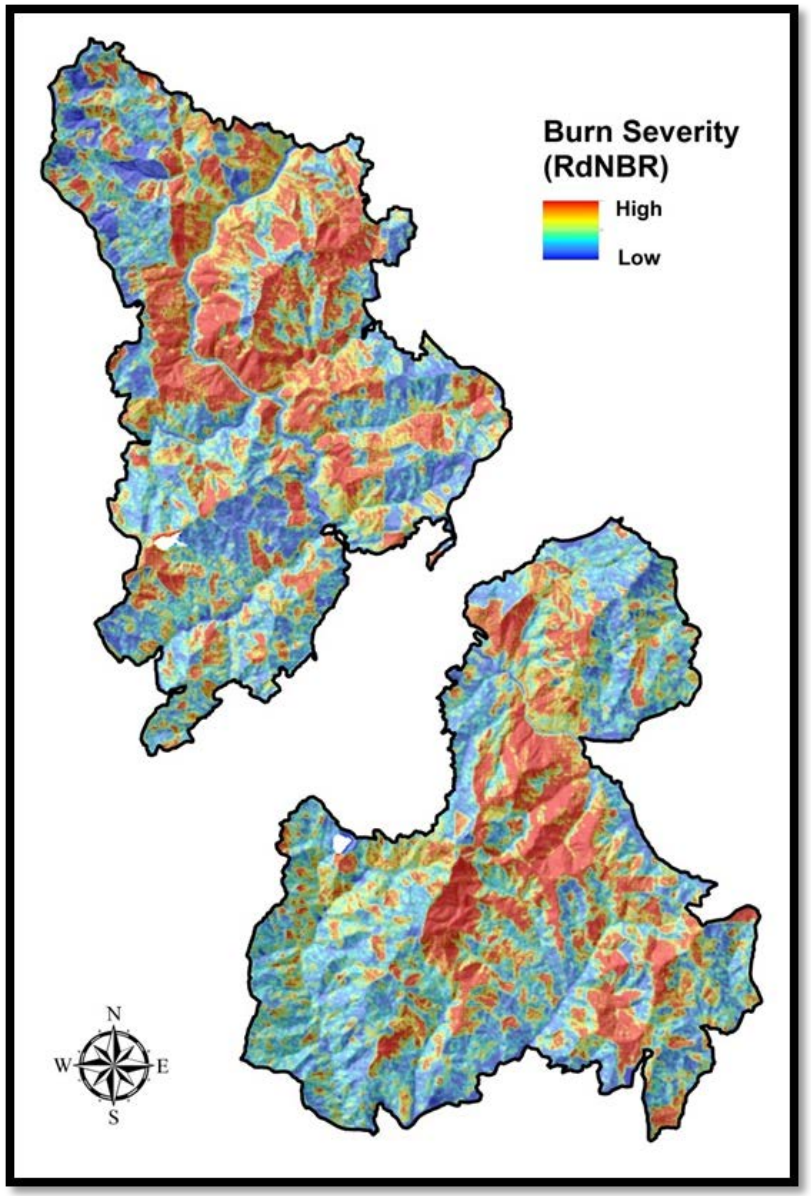
https://www.wunderground.com/blog/JeffMasters/us-lightning-strikes-may-increase-50-due-to-global-warming

Response Variable - RdNBR

Relative differenced normalized burn ratio (RdNBR)

Landsat 8 OLI Product from Monitoring Trends in Burn Severity www.mtbs.gov

1. NIR = near-infrared band, MIR = mid-infrared band
2. NBR = (NIR – MIR) / (NIR + MIR)
3. dNBR = NBR_{pre} - NBR_{post}
4. RdNBR = dNBR/sqrt(abs(NBR_{pre}/1000)



Explanatory Variables

Fuels

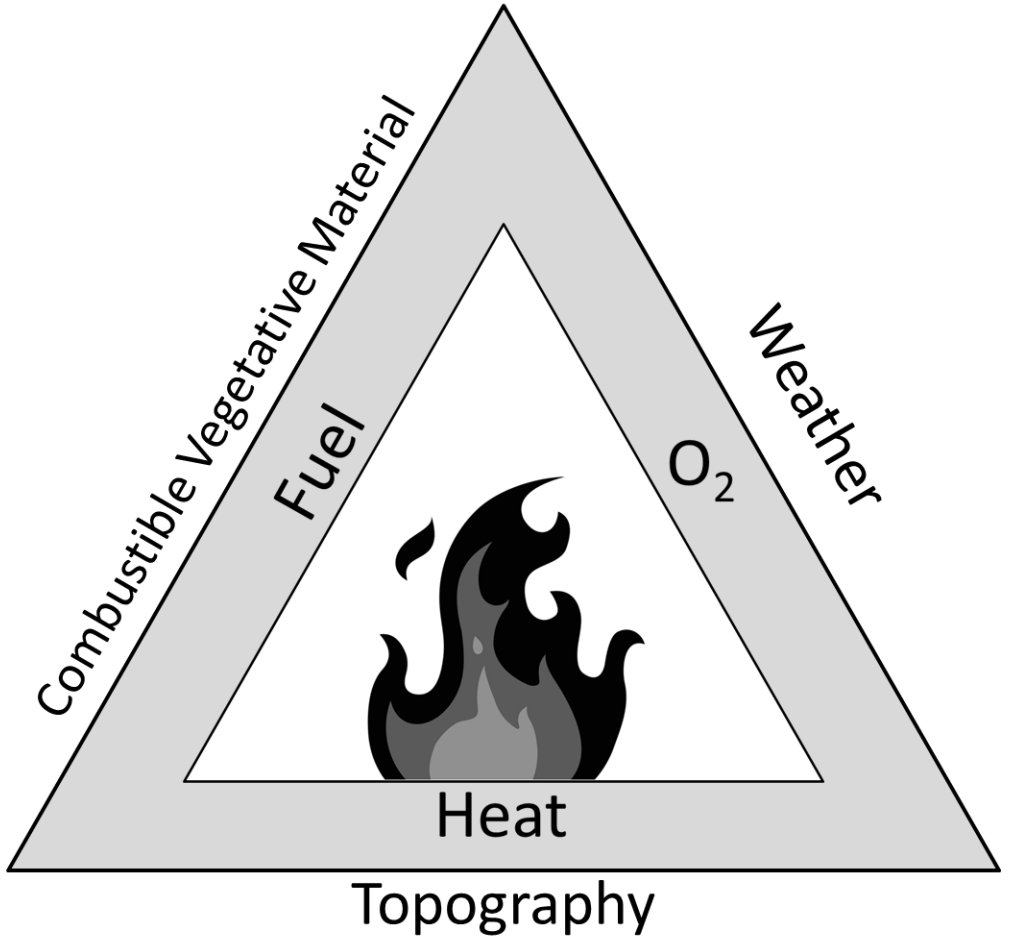
- Biomass
  - pre-fire GNN imputation map http://lemma.forestry.oregonstate.edu/
- Stand age
  - Landsat disturbance mapping http://landtrendr.forestry.oregonstate.edu/
  - amended with GNN age estimate for older forests

Weather

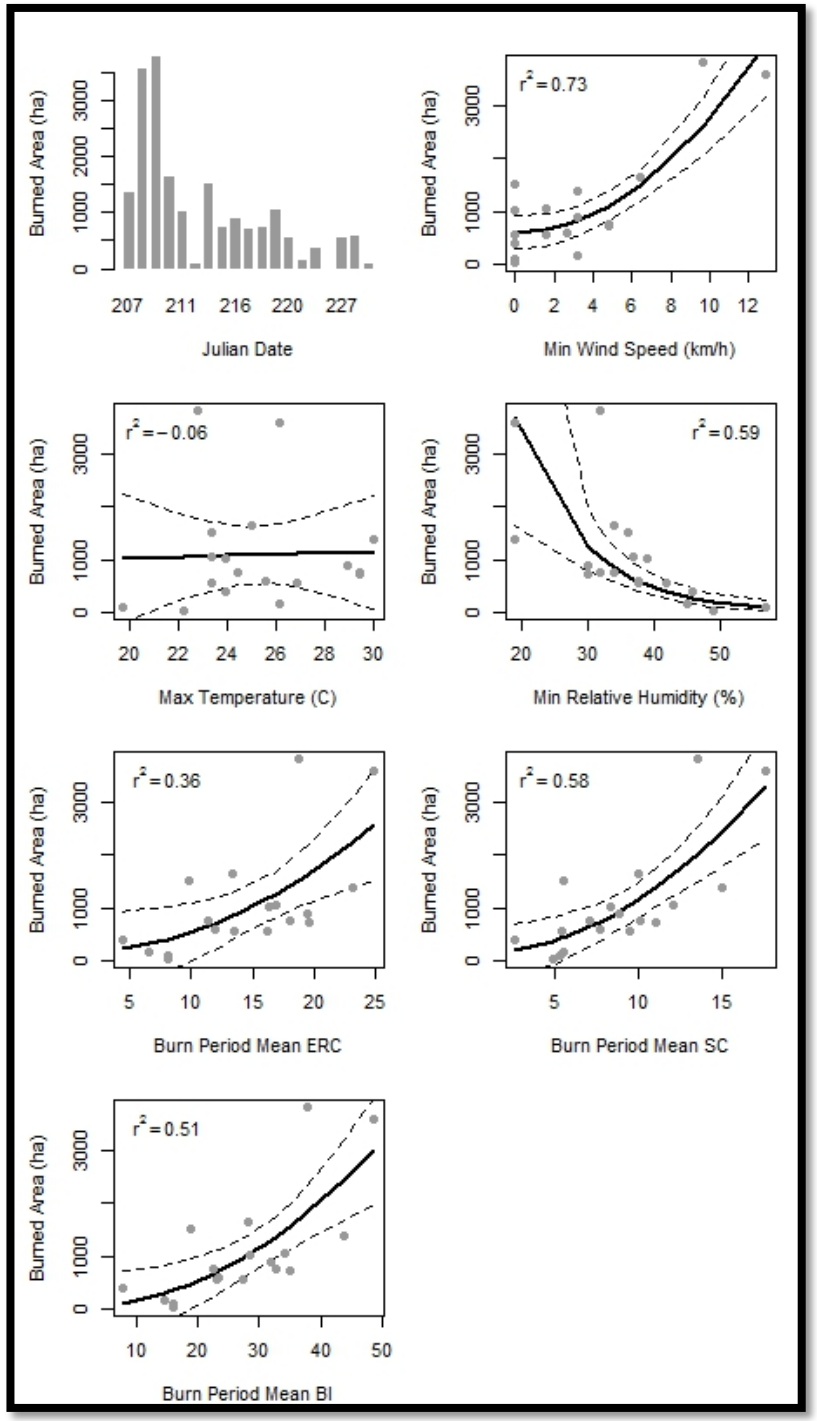
- Calculated from Calvert RAWS during burn period and spatially extrapolated to daily fire progression map

Topography

- Elevation, slope, topographic position, heat load



Daily burned area (ha)



Daily mean RdNBR (ha)