Pyrosilviculture: The Need for a New Approach to Increasing the Pace and Scale of Forest Treatments

North, M.P., R.A. York, B.M. Collins, M.D. Hurteau, G.M. Jones, E.E. Knapp, L. Kobziar, H. McCann, M.D. Meyer, S.L. Stephens, R.E. Tompkins, and C.L. Tubbesing. 2021. Pyrosilviculture needed for landscape resilience of dry western U.S. forests. Journal of Forestry. Doi:10.1093/jofore/fvab026.

No matter how much money, human resources or new technology is thrown at it, in California landscapes, **fire is inevitable and increasing in frequency and severity with climate change.**

So, the pivotal question is: What kind of fire do we want?

Fires that escape suppression during extreme weather conditions?

OR

Intentional fire under weather, human resource, and smoke dispersal conditions of our choosing?

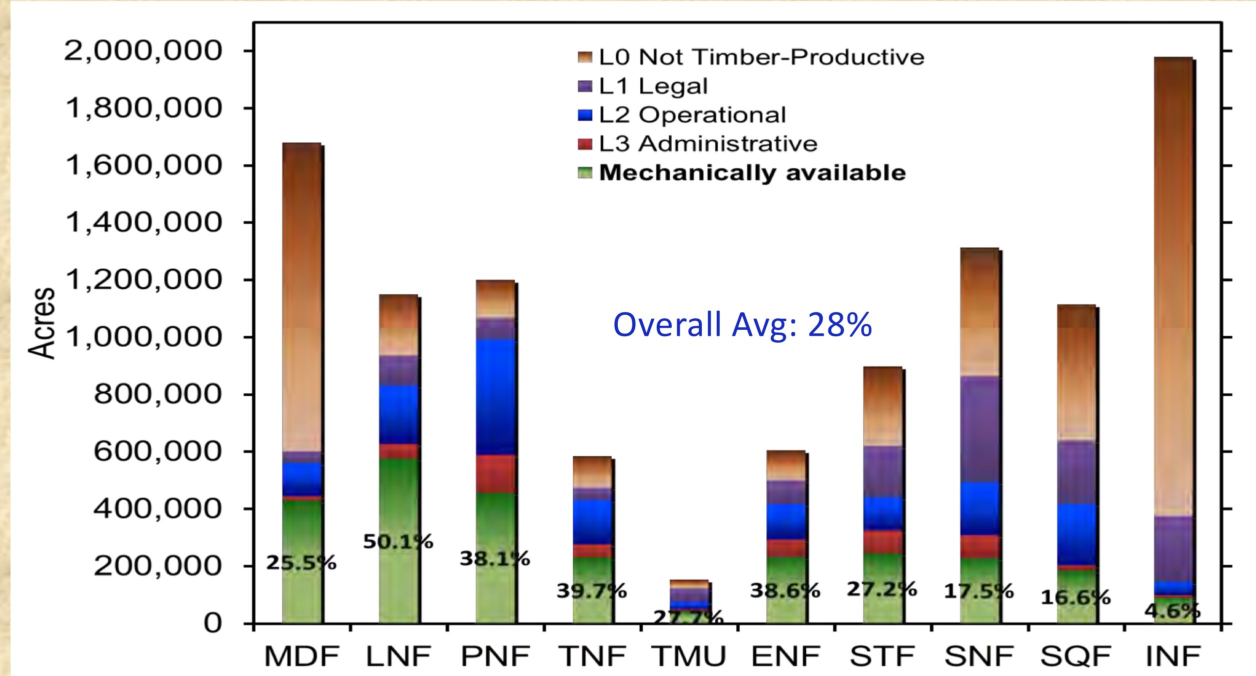
BUT: Smoke regulations, lack of crews, liability can make managed fire (Rx and 'for resource benefit') constrained and difficult

Alternatively: Can we get serious about thinning and significantly change wildfires?

The area where mechanical thinning is feasible is pretty constrained (28% of Sierra NFs)

Constraints: Reduction in FS Acres Available for Thinning Treatments by NF

- Brown: remove acres of rock, water, minimal tree cover
- Purple: remove wilderness, roadless areas
- Blue: remove acres too steep or far from road
- Red: remove special features such as spotted owl nests, riparian areas
- Green: acreage that remains and % of total acres on that NF



Thinning projects: lots of planning hoops for relatively small acreage, sensitive species constraints, and often expensive

Modoc, Lassen, Plumas, Tahoe, T. Basin Eldorado, Stan., Sierra, Sequoia, Inyo

National Forests in the Sierra Nevada from North➔South

North, M., A. Brough, J. Long, B. Collins, P. Bowden, D. Yasuda, J. Miller and N. Suighara. 2015. Constraints on mechanized treatment significantly limit mechanical fuels reduction extent in the Sierra Nevada. Journal of Forestry 113: 40-48.

In addition, perhaps the FS's biggest roadblocks are lack on funding and dwindling staff

Solutions?

Well maybe, there's a more practical solution…

- Diagnosis the problem: What's impacting most of the landscape? What's limiting the scale of current management practices?
- What needs to change and is it practical?
- Conditions: must be realistic, satisfies different "ologists" and generates its own funding

Pyrosilviculture*: directly increase fire use in dry western conifer forests by coordinating and consolidating prescribed burns, managed wildfire, and modified mechanical treatments to reduce fuels and tree density at large scales

What is Pyrosilviculture? Both Stand and Landscape Applications: Focus on landscapes today

* For stand level application see: York, R.A., H. Noble, L. Quinn-Davidson, and J.J. Battles. In press. Pyrosilviculture: Combining prescribed fire with gap-based silviculture in mixed-conifer forests of the Sierra Nevada. Canadian Journal of Forest Research: doi.org/10.1139/cjfr-2020-0337.

Pyrosilviculture		
Attributes:	Stand*	Landscape
Definition	• Use fire to directly meet management objectives • Alter silvicultural treatments to better incorporate future prescribed fire	• Coordinate and consolidate mechanical, prescribed burn, and managed wildfire treatments to reduce fuels and tree density to moderate large-scale stressors.
Objectives	• Create conditions (structures and species compositions) such that future prescribed fires can more feasibly be applied • Apply prescribed fire as the preferred tool for reducing surface fuels • Sustain fuel conditions, so that a higher proportion of wildfires burn with predominantly low-moderate severity in treated stands	• Treat large forested areas where the beneficial effects of prescribed fire, managed wildfire, and mechanical treatments are synergistic • Fire occurs on a scale such that its function as a crucial ecosystem process is restored • Limit high-severity wildfire extent such that type conversion is minimized.
Operational Means	• Increase near- and long-term opportunities for future fire use by adjusting planting and thinning prescriptions • Apply prescribed fires at stand scales (<125 ac) • Prescribed fire schedules are designed around specific management objectives	• Leverage low and moderate severity areas in wildfires as initial 'treatments' • Identify managed wildfire zones • Implement anchor, ecosystem asset, and revenue treatments • Expand fire objectives to include density reduction, heterogeneity and species/phenotypic selection
Measures	• Fuel load monitoring • Wildfire behavior modeling • Fire effects that are identified as enhancing objectives (e.g. minimizing crown damage)	• General objectives[1] derived from Natural Range of Variation (NRV)[2] for: • Forest conditions—tree density, structure, composition and spatial pattern. • Fire behavior—percentage and patch size of high-severity fire
Limitations	• Risk, resource, and regulatory barriers around fire use • Outcomes are variable compared to non-fire treatments, • Perception of fire's incompatibility with timber objectives	• Crew and equipment availability for large operations • Increased days of smoke production • Potential liability • Institutional caution
Opportunities	• Use traditional tools, such as leaf area index and relative density index to manage stand structure	• Treat landscapes while providing habitat for sensitive species

None of this is new: Many managers are already using elements of pyrosilviculutre

But what may be different is:
Leveraging the hand we've been dealt

Coordination:
Fire can be used for more than site preparation, fuels reduction or fuels break maintenance

Thinning can be used for more than reducing and breaking up fuels, radial growth release and shifting species composition.

Bottom line:

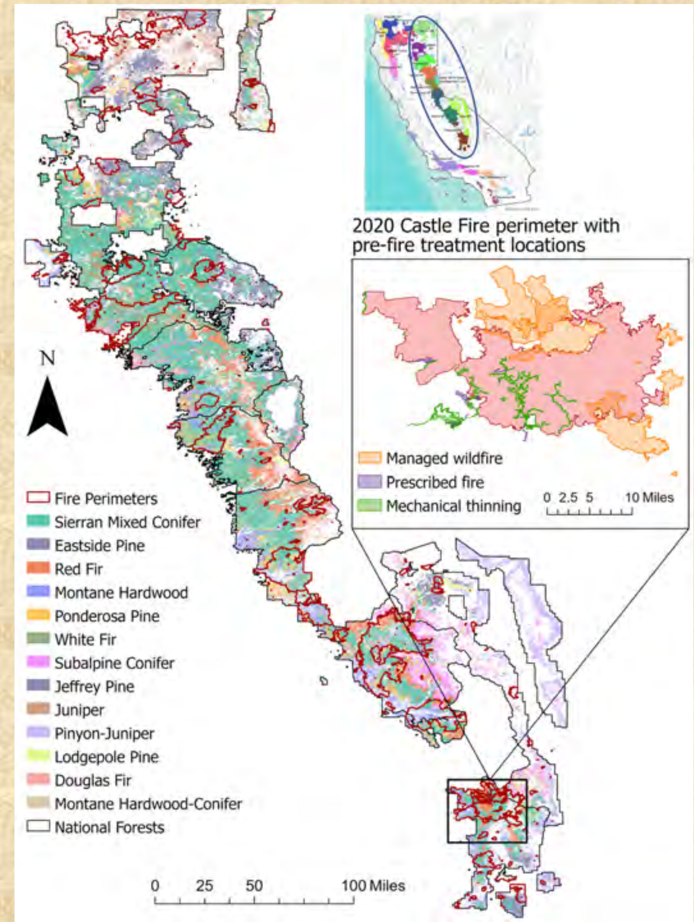
Shift the focus from getting stands precisely designed and fire resistant to broadly reducing fuels and fostering heterogeneity on large landscapes.

Diagnosis: What's the Current Pace & Scale of Fuels Treatments in the Sierra Nevada?

1st step: Estimate acres of Forest Service land that use to burn each year before European settlement?

Total FS Acreage	13,015,888		
Forest Type (FT):	Area (ac)	MFRI	Avg Burned (ac/yr)
Mixed Conifer	3,052,375	14	218,027
Eastside Pine	1,102,164	6	183,694
Red Fir	755,787	40	18,895
Montane Hardwood	630,241	11	57,295
Ponderosa Pine	469,630	5	93,926
White Fir	452,755	25	18,110
Hardwood/Conifer	307,891	14	21,992
Lodgepole Pine	226,415	37	6,119
Douglas-Fir	87,125	24	3,630
Total: Frequent, low- to mod-severity fire regime	7,084,383		621,688
Sub Alpine	408,466	132	3,094
Pinyon/Juniper	364,181	150	2,428
Western Juniper	277,939	83	3,349
Total: Infrequent, high-severity fire regime	1,050,586		8,871
Total: All forest types	8,134,969		630,559

252,000 ha



2nd step: What are current rates of Forest Service thinning and burning treatments?

Average annual acreage of F.S. treatments by type tallied by unique footprint[1] and accomplishment[2], overlap[3] size, mean/median treatment size & distance between treatment units within a project for NF lands between 2011-2020.

Treatment Type:	Unique Footprint[1] (acres)	Total Accomplished [2] (acres)	Mean size in acres (range)	Median size (acres)	Median distance (ft) between treatments within a project
Mechanical (Mech)	21,211	50,374	36 (0.1-5,249)	13	4623
Prescribed Burn (Rx)	11,861	22,214	40 (0.1-1,298)	13	
Managed Wildfire (Man)	18,919	20,138	2,877 (0.8-82,230)	295	
Mech & Rx	10,861	(23,200[3])			
Rx & Man	58	--			
Mech & Man	341	--			
Mech/Rx/Man	105	--			
Total:	63,357	92,726			

[1] Stacked treatment polygons are condensed into one footprint

[2] Total treatment acreage tallied regardless of overlap

[3] Overlapping acres of treatment (i.e., the same area was thinned and then burned)

Treatments compared to historical levels:

Unique footprint (63K): 10%

Overlapping (93K): 15%

Avg mechanical size: 36 ac

Avg Rx burn size: 40 ac

Avg manage wildfire size: 2900 ac

Avg dist. between trt: 0.8 miles

3rd step: During this same decade, how much burned in wildfires of different severity, and intersected a treatment

Year:	Total Fire Ac	Unburned Ac (%)	Low-Severity Ac (%)	Moderate-Severity Ac (%)	High-Severity Ac (%)	Treated acres intersected by wildfire
2011	35,765	NA	NA	NA	NA	1,622
2012	132,033	18,311 (13.9%)	49,695 (37.6%)	36,139 (27.4%)	27,888 (21.1%)	2,506
2013	237,497	35,038 (14.8%)	80,889 (34.1%)	72,085 (30.4%)	49,485 (20.8%)	11,293
2014	189,505	16,281 (8.6%)	53,185 (28.1%)	51,983 (27.4%)	68,056 (35.9%)	15,139
2015	162,574	40,329 (24.8%)	52,877 (32.5%)	42,172 (25.9%)	27,196 (16.7%)	3,900
2016	82,086	13,467 (16.4%)	22,529 (27.4%)	20,840 (25.4%)	25,250 (30.8%)	15,136
2017	186,232	37,565 (20.2%)	94,824 (50.9%)	37,071 (19.9%)	16,772 (9.0%)	25,350
2018	244,654	46,900 (19.2%)	108,292 (44.3%)	61,520 (25.1%)	27,942 (11.4%)	11,711
2019	99,112	NA	NA	NA	NA	10,977
2020	902,991	NA	NA	NA	NA	104,804
Avg/yr	227,245	29,699 (16.8%)	66,042 (36.4%)	45,973 (25.9%)	34,656 (20.9%)	38,211*

Total acres and acres by severity class for wildfire activity from 2011-2020

Wildfire burning >2 times area of FS treatments

11% of wildfire ac run into a FS treatment

>110K ac burn at low and moderate severity

* Avg intersected for 2017-2020 only

- Three main take homes from this analysis: 1st Wildfire is having the largest impact

Leverage the beneficial work done in some parts of wildfires

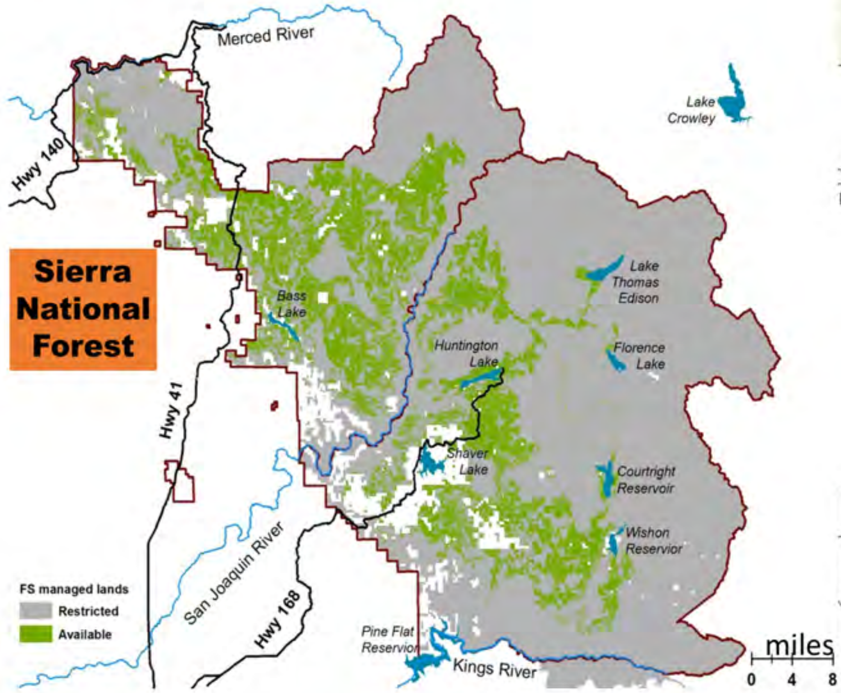
- Wildfire acreage (227,000 ac/yr) burns more than all management treatments combined.

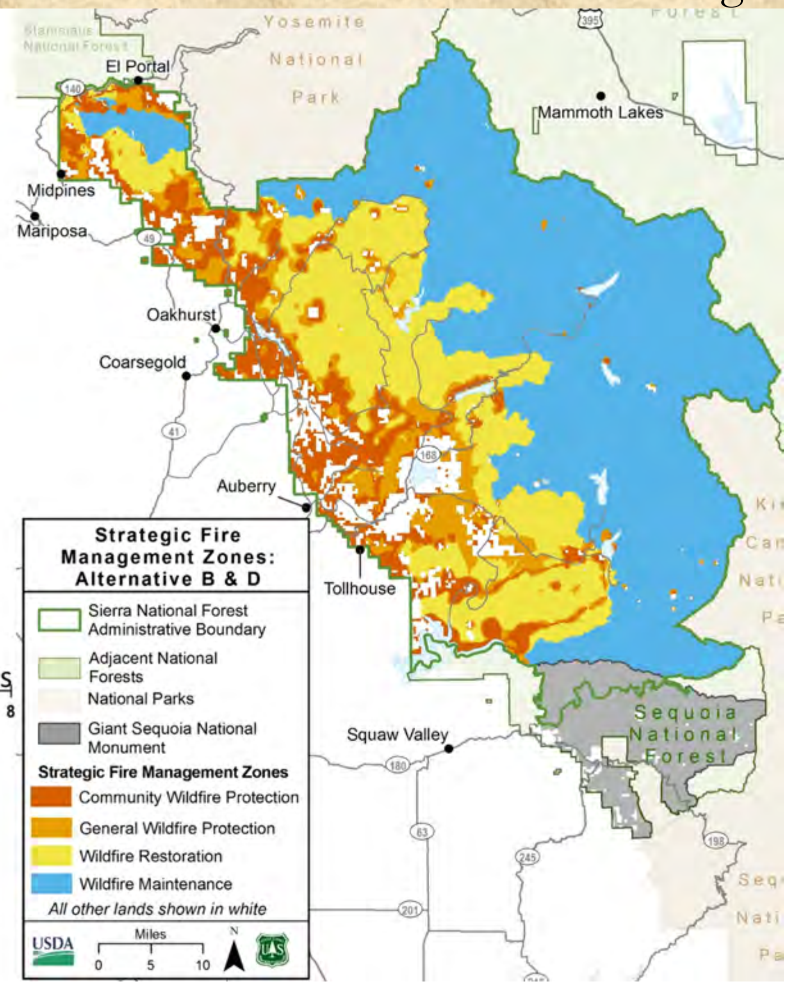
- Of this acreage, about half is low (66K ac) to moderate (46K ac) severity
- However, currently most management is focused on possibly salvaging and planting the high-severity areas
- Suggestion: After the wildfire 'treatment' (low/modernity severity acreage) thin any remaining ladder fuels to 'harden' site against crown fire& create the spatial pattern (ICO) characteristic of frequent-fire forests.
- Later, use prescribed fire to reduce larger surface fuels such as snags that often fall to the ground 7-20 years after the wildfire.
- Leveraging these low and moderate severity burns would increase treatment rates by 250-325%.

2nd most impactful change: Identifying Managed Wildfire Zones

- On average, managed wildfire 'treatments' (2800 ac) are 70 times the size of mechanical thinning and Rx burning

In the Sierra N.F.'s new forest plan, 70% of the NF is now in a 'managed wildfire zone'





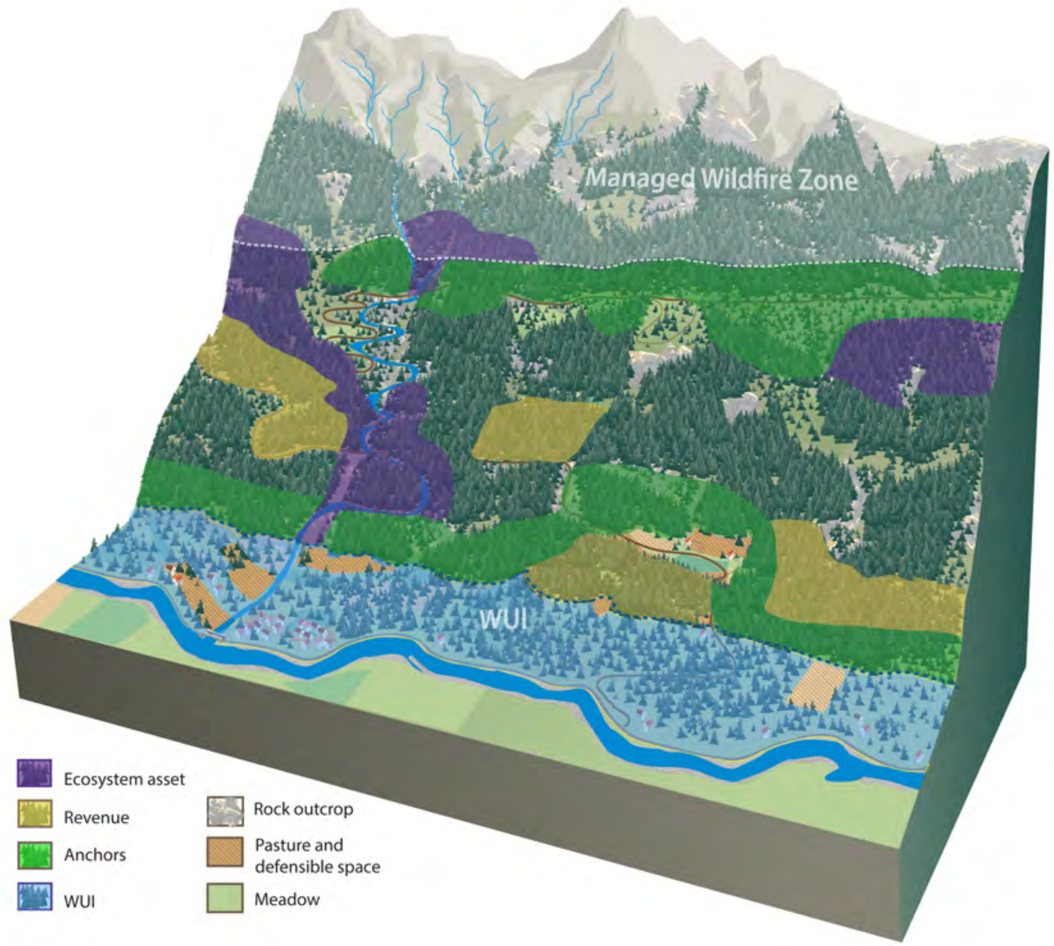
Left: Area that can be mechanically treated on the Sierra NF

Right: In the Sierra's new forest plan, the yellow and the blue are areas where natural (lightning) ignitions will be left to burn. Note that much of this matches the mechanical constraint area (gray area in the left figure)

3rd Problem: Treated areas are too small and dispersed to increase fire use or modify burn severity beyond the treated unit

- Following WDSS protocol which use roads, ridges, and natural features to set boundaries
- Fuels treatments are coordinated to form a large-scale (>5,000 ac) box for applying fire.

Landscape schematic of how 3 proposed forest treatments; anchors, ecosystem assets, and revenue might be placed to provide a boundary 'box'.

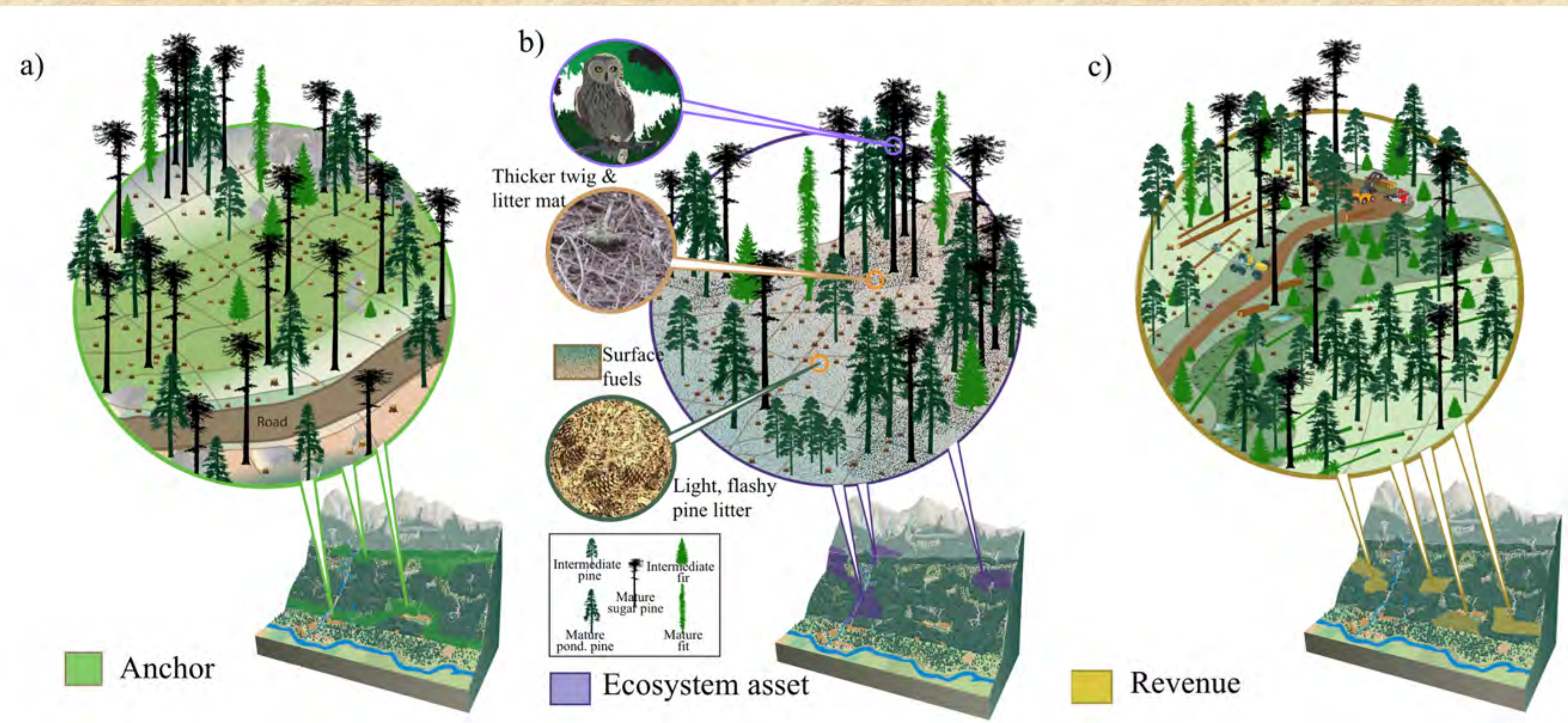


Stand-level schematics of three proposed thinning treatments:

a) an anchor, showing near the road, the backstop (heavy fuels reduction leaving only large, spatially separated pines) grading into a more mixed-species forest with a fire resistant spatial pattern (i.e., individual trees, clumps of trees and openings [ICO]) where the fire leaves the anchor;

b) an ecosystem asset where most thinned trees are ladder fuel size, an ICO pattern is created, and pine litter is dispersed in openings to facilitate fire spread

c) a revenue thinning where intermediate and larger fire-sensitive fir are removed for saw log processing.



Are these different from current fuels treatments?

All are focused on getting fire into the forest, scale up its footprint, and financing it

Large-scale application of fire isn't possible without relaxing how we use and evaluate it

- Current use of managed fire is often limited to reducing surface and ladder fuels
- Due to a focus on not damaging merchantable trees, fire managers sometimes have very constrained targets (i.e., <15% overstory mortality).
- Large-scale fire is a 'blunt tool' and should not be compared against what thinning could have achieved

Large-scale fire should have silvicultural **and ecological** objectives, and be oriented toward increasing pace and scale

A) Density reduction (that sometimes kills some overstory trees)
B) Tree spatial heterogeneity (individual trees, clumps of trees and openings)
C) Fire-tolerant species (ex. pines) left in hotter drier and fire-sensitive species left in wet locations. Fire selecting for individual with phenotypes including thicker bark, earlier branch abscission

But, large-scale fire's "relaxed" targets can't meet the specific structures of sensitive species, riparian set backs, etc.

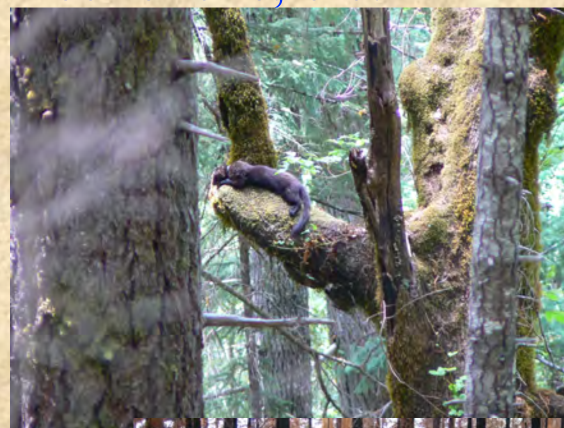
The spotted owl has been perhaps the most impactful of these constraints

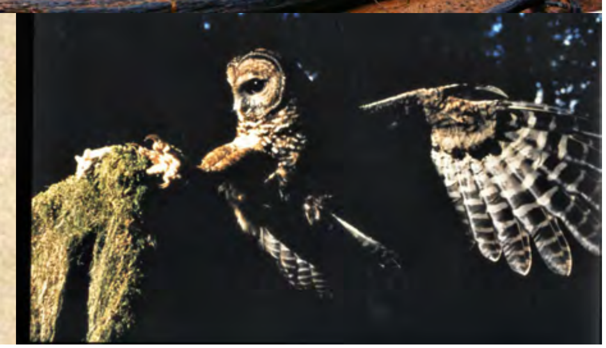
12-15 years ago, some leading owl biologists suggested it was best to stop cutting and leave the forest alone

No longer…Wildfire has wiped out some long-term study areas and the recent focus on creating forest heterogeneity provides a range of habitats that support different prey and forest structures that improve foraging

Climate change and wildfire is forcing specialists to realize a fine-filter management approach can be a dead end

Static goals (preserve current habitat, leave some areas alone) need to be replaced with building forest adaptability





Clockwise from top left: Pacific fisher rest on legacy large oak, black-back woodpecker, owl nest site burned at high severity, spotted owl capturing mouse

Nice idea but large-scale Rx burning is not practical because (ARB restrictions, liability, costs, lack of crews, negative public response…)

Yet consider:
Of 8,000,000 Rx acres burned each year in the US, 7 million are in the Southeastern[1].

The SE has some key advantages (flat topography, wetter fuels and weather), but part of their success is using versions of the proposed three thinning treatments and 'relaxed' fire goals.

SW Australia (Perth area) burns >300,000/yr. Managers say* once about 20-25% of the landscape had strategically placed treatments (anchors), they reached a tipping point where using large-scale fire became much easier.

Even in California there are areas of large-scale fire use (Yosemite and SEKI NPs, Sequoia NF), that share 2 key attributes: they build anchors creating large remote (from structures) blocks and managers focused on acreage rather than precise stand structure targets.

[1] Melvin M. 2018. 2018 National prescribed fire use survey report. Technical Report 03-18 Coalition of Prescribed Fire Councils, Inc.
*Sneeuwjagt, R.J., T.S. Kline, and S.L. Stephens. 2013. Opportunities for improved fire use and management in California: lessons from Western Australia. Fire Ecology 9:14-25.

Pyrosilviculture Benefits

- Mechanical thinning often limited in scale and long review period, as Rx fire can be scaled up with programmatic burn plan for entire N.F.
- Fire reintroduces a key process and may provide better forest adaptability/resilience than target thinning prescriptions
- Maintenance of reduced fuels needs a large scale, repeatable treatment.

But, some changes are needed

- Will need a western US prescribed fire training center to develop crews dedicated to using fire for resource benefit and to coordinate equipment and resources across agencies
- Will need longer duration permits to carry out large burns
- Could employ a push/pull Yosemite strategy: under poor weather and smoke dispersal, fire is pushed into low fuel areas and then pulled across landscape when conditions are favorable


Questions?
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