WESTCARB Regional Partnership

Terrestrial Sequestration

John Kadyszewski and Sandra Brown
Co-Principal Investigators for Terrestrial Pilots
Winrock International

October 19, 2010

Terrestrial Partners

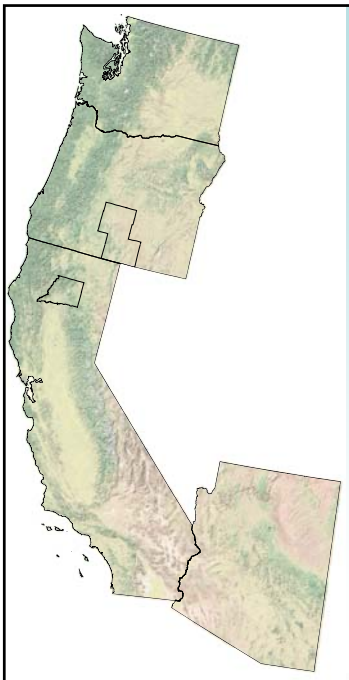
Fire
- •UC Berkeley (fire study)
- •Spatial Informatics Group (fire study)
- •Oregon State University
- •USFS PSW Research Station
- •USFS PNW Research Station

California
- •CALFIRE
- •Climate Action Reserve (CAR)

Oregon
- •Oregon Department of Forestry
- •Greenwood Resources
- •Climate Trust

Shasta County, CA
- •Western Shasta Resource Conservation District
- •Wheelabrator
- •W.M. Beaty and Associates
- •Pacific Forest Trust
- •Bascom Pacific, LLC
- •Bureau of Land Management
- •Pacific Gas & Electric

Lake County, OR
- •Lake County Resources Initiative
- •Collins Company
- •Fremont National Forest



Terrestrial Projects

All WESTCARB
- •Analysis of impact of fuels treatment on greenhouse gas emissions from wild fires
- •Analysis of potential for sequestration by planting hybrid poplars

California
- •Completion of baseline analysis

Shasta County, CA
- •Pilot study on afforestation
- •Pilot study on fuels treatment
- •Pilot study on forest management (Bascom Pacific)
- •Pilot study on forest management (LaTour State Forest)

Oregon

Lake County, OR
- •Pilot study on fuels treatment
- •Analysis of potential for siting of biomass energy plant

Arizona
- •Feasibility study on potential for riparian planting

Washington
- •Development emissions and potential emission reductions

WEST COAST REGIONAL CARBON SEQUESTRATION PARTNERSHIP 3

AFFORESTATION PILOTS

12 sites covering 476 acres

WEST COAST REGIONAL CARBON SEQUESTRATION PARTNERSHIP 4

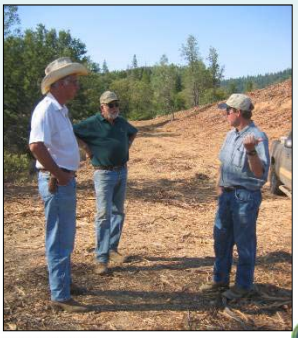
Initial Outreach

- Stakeholder Meetings
- Presentations at Local and Regional Meetings
- Word of Mouth
- More than 400 Landowners Contacted Through Mail
- +50 Interest Surveys Given
- 20 Site Visits Resulted in 17 Plans

Landowner Outreach

Ongoing communication with landowners vital throughout project implementation and included:

- Climate Change and Forestry Education
- Contract Negotiations
- Scheduling of Activities
- Project Updates

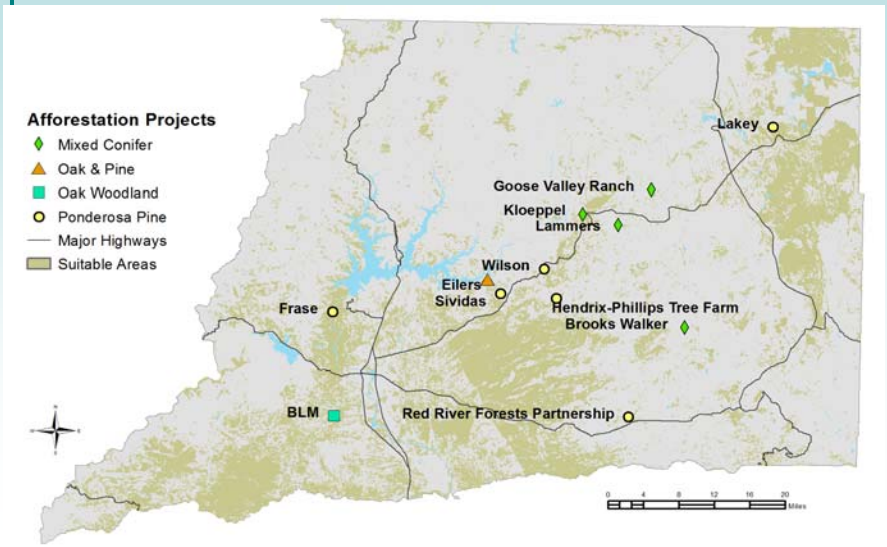


Community Outreach

Traditional and Non-Traditional Venues:

- Local/Regional Meetings
- Newspaper/Newsletter Articles
- Videos
- County Fairs and Festivals
- Website, Webzines, YouTube, Facebook
- Education Community

Shasta Afforestation Pilot Projects



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Red River	98	Ponderosa pine	21	99	21	73
Brooks Walker	7	P. pine & red fir	3	73	37	100
Hendrix-Phillips	20	Ponderosa pine	24	93	15	67
Goose Valley Ranch	60	P. pine, Douglas fir, incense cedar	20	83	22	80
Lammers	50	Ponderosa pine & Douglas fir	15	69	14	74
Frase	43	Ponderosa pine	0	93	33	85
Kloeppel	51	Ponderosa pine & Douglas fir	10	84	38	98
Sivadas	46	Ponderosa pine	44	97	-12	43
Eilers	20	P. pine (18 ac)	0	72	18	64
		P. pine & oak (2 ac)	0	52	15	53
Wilson	14	Ponderosa pine	31	90	6	60
Lakey	60	Ponderosa pine	0	75	20	69
BLM	7	Oak	0	25	8	24

WEST COAST REGIONAL CARBON SEQUESTRATION PARTNERSHIP 9

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WEST COAST REGIONAL CARBON SEQUESTRATION PARTNERSHIP 10

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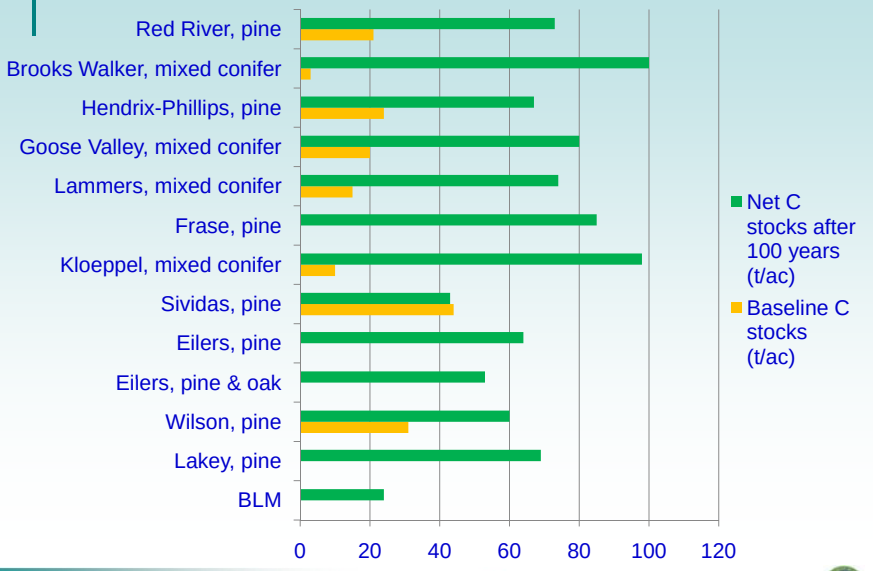
Seedlings @ end of long, dry growing season 2008
- ➢90% survival

Hendrix Project

WEST COAST REGIONAL CARBON SEQUESTRATION PARTNERSHIP 14

September 2010

Afforestation Baseline and Project Stocks

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Bioenergy trials
- Red River site
- 21 tons/ac
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Afforestation Costs

Project	Acreage	Total Cost	Cost per Acre
Red River Forests	98	$81,532	$832
Brooks Walker	7	$8,854	$1,265
Hendrix-Phillips	20	$24,453	$1,223
Goose Valley	60	$61,958	$1,033
Lammers	50	$42,885	$858
Frase	43	$25,812	$600
Kloeppel	51	$45,870	$899
Sivadas	46	$35,805	$778
Eilers	20	$7,084	$354
Wilson	14	$18,198	$1,300
Lakey	60	$28,919	$482
BLM	7	$13,160	$1,880

15 Year-Old Plantation

Both areas planted after the same wildfire but:

No Weed Control

Weed Control

After new forest is established, landowners need to control brush to assure fire resilient forests with large trees vs. cycle of brush/burn/brush

Outreach - Lessons Learned

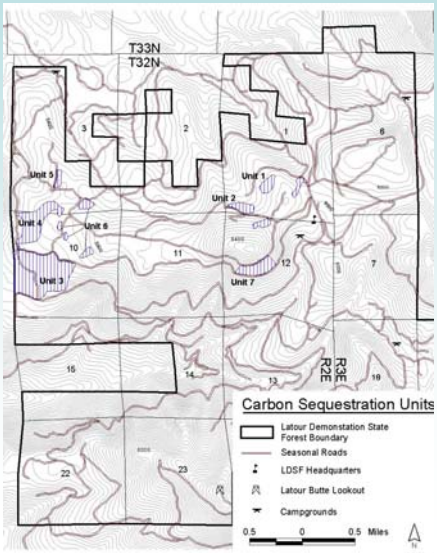
- Interest in Terrestrial Sequestration, Carbon Markets and Climate Stewardship is Increasing
- Landowners
  - Value Privacy
  - Cautious with Government and Property Rights Restrictions
- Time Needed to Develop
  - Understanding
  - Trust
  - Relationships

Shasta Afforestation Pilot Project Findings

- Project baselines consisted of a variety of brush species, mostly fairly dense. Baseline carbon stocks ranged from zero, for a project that had recently burned in a wildfire, to 34 metric tons of carbon per acre, on a project with dense old-growth Manzanita.
- Projects were planted to ponderosa pine, mixed conifer stands, or native oaks. After 60 years, net carbon stocks on conifer plantings ranged from 11 t C/ac to 73 t C/ac. The native oak planting had net carbon stocks of 24 t C/ac after 60 years.
- Survival of planted conifer seedlings was high, despite limited rainfall in the year of planting.
- The project costs ranged from $354/ac to $1,880. The mean breakeven offset price at 40 years is $17.47/t CO_2 and the median is $10.62/t CO_2.

FOREST MANAGEMENT

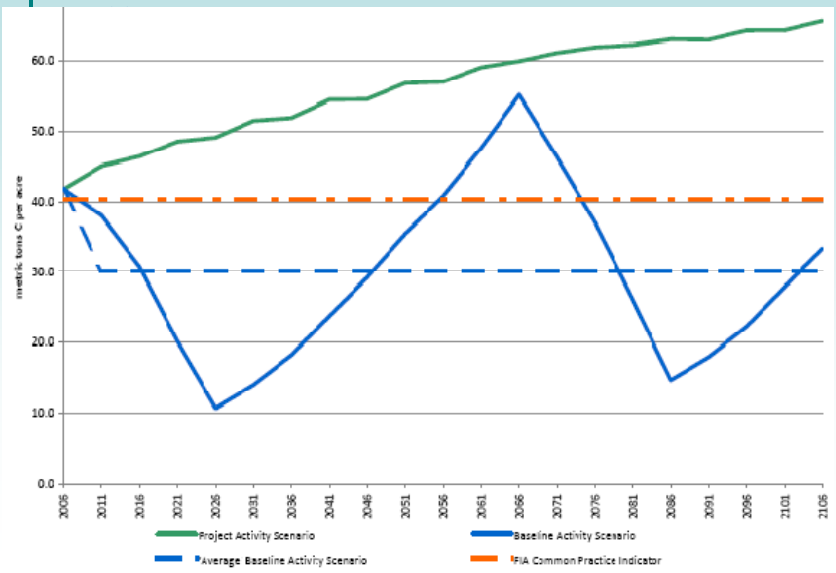
LaTour Demonstration State Forest



Bascom Pacific Summary

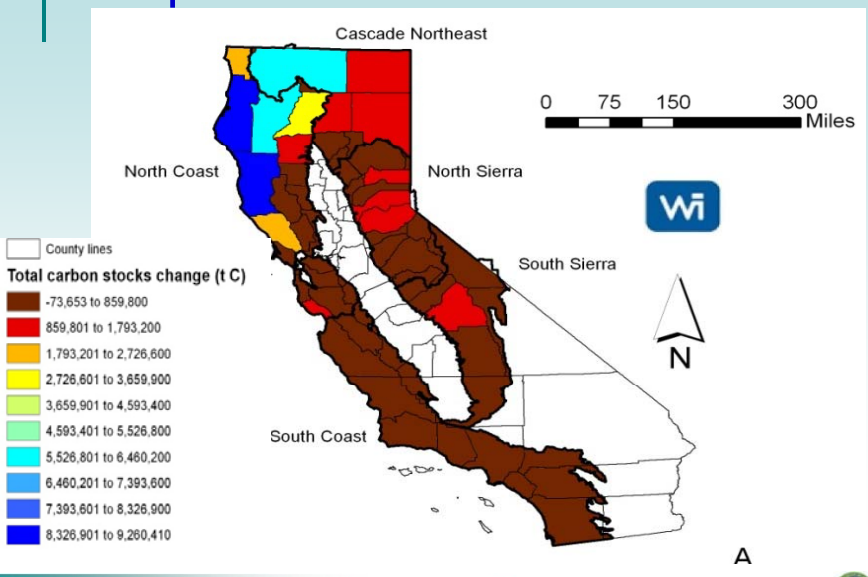
- Pacific Forest Trust helped develop Improved Forest Management Project near Mt. Shasta, CA
- 9,202 acre Sierra mixed conifer forest
- CA Forest Practices baseline compared to Conservation Easement project
  - Reductions of ~ 1 Million metric tons CO_2e
  - Effect of wood products on sequestration is minimal
  - Revised CAR protocols reduce total sequestration

Effects of Project Protocol Revisions FPP

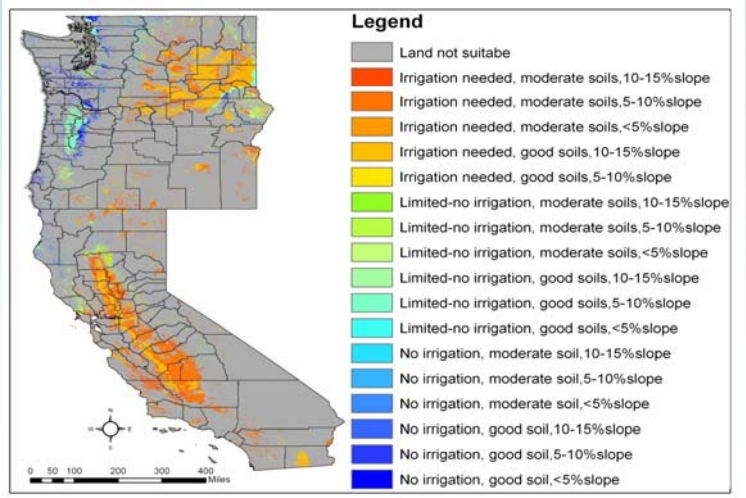


REGIONAL CHARACTERIZATION

Completed California Baseline



Suitability map for hybrid poplar plantations: Suitable lands include all croplands, rangelands and grasslands based on NLCD 2001.



Note: The areas in the map identified as available for hybrid poplar planting are all croplands, pastures, rangelands and grasslands (data from NLDS 2001).

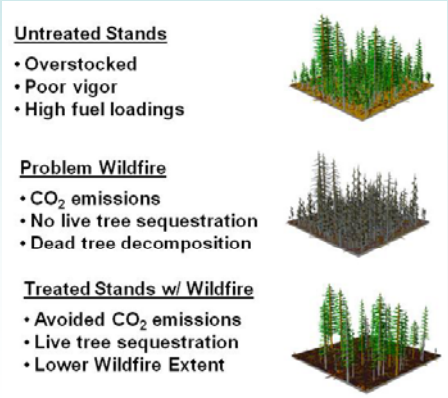
Additional Contributions

- Afforestation of Arizona riparian areas possible but expensive
- Analysis of other emissions reductions options linked with terrestrial sequestration
  - Preliminary evaluation of removals for site prep at afforestation sites as fuel source for bioenergy
  - Preliminary evaluation of hazardous fuel removals as fuel source for bioenergy
- Quantification of fuel supply for Lake County bioenergy plant
- Preliminary review of options for linking terrestrial sequestration with geologic sequestration

Additional Contributions

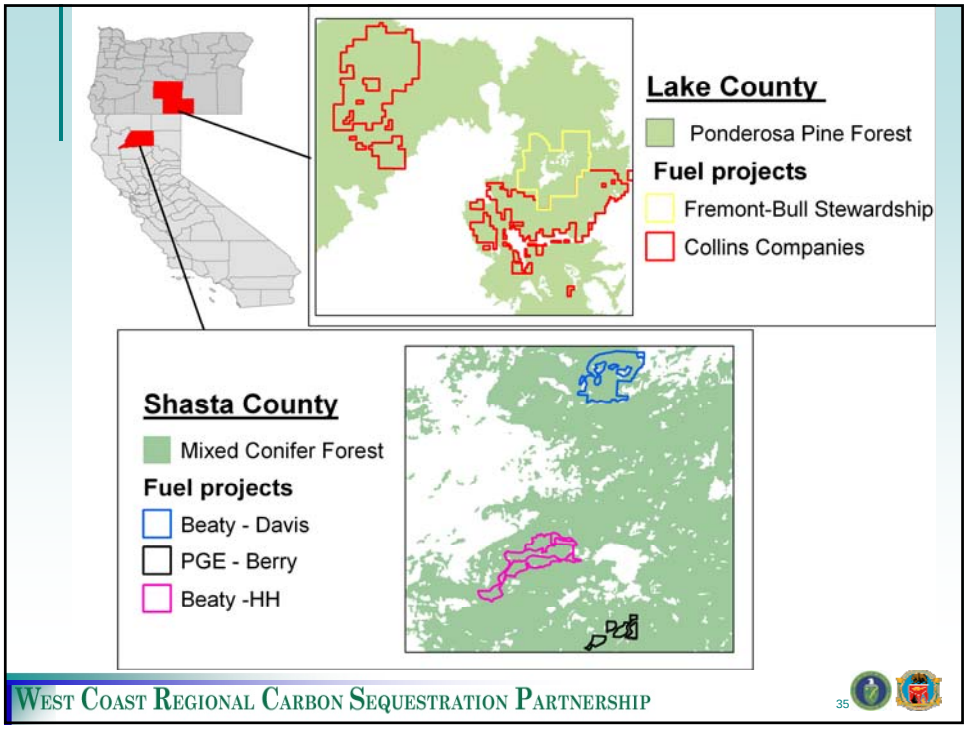
- Terrestrial Best Practices Manual
  - Overview of methodologies and results for all forest carbon project types
  - Case study of accounting for hazardous fuels projects
- Data from CA, WA, OR for Carbon Atlas
  - Baseline carbon map
  - Carbon accumulation potential on agriculture and range after 20, 40, 80 years
  - Conversion costs for agriculture and range lands after 20, 40, 80 years

IMPACTS ON NET GHG EMISSIONS FROM FUEL TREATMENT AND WILDFIRE



Studies have indicated a net benefit of fuel treatment on GHG emissions from wildfires

- Previous studies have not considered all factors in the fuel- treatment-fire issue
  - Studies typically conducted for a different purpose
  - Do not have full atmospheric accounting
  - Several assume fire is a given rather than a relative probability
  - Incomplete accounting of treated/extracted materials


Lake County
Ponderosa Pine Forest
Fuel projects
Fremont-Bull Stewardship
Collins Companies
Shasta County
Mixed Conifer Forest
Fuel projects
Beaty - Davis
PGE - Berry
Beaty -HH
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Before
After fuel treatment
Critical elements of framework:
1. Annual Fire Risk
2. Emissions as a Result of Treatment and Fire
3. Removals from forest regrowth after treatment and fire
4. Retreatment
5. Shadow Effect
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Framework for estimating emissions & removals from hazardous fuel reduction

The net emissions or removals in year one are calculated as

$$[(Ct + Cw + Ce - Cb) * (1 - risk)] + [(Ctf + Cw + Ce - Cbf) * (risk)]$$

Where

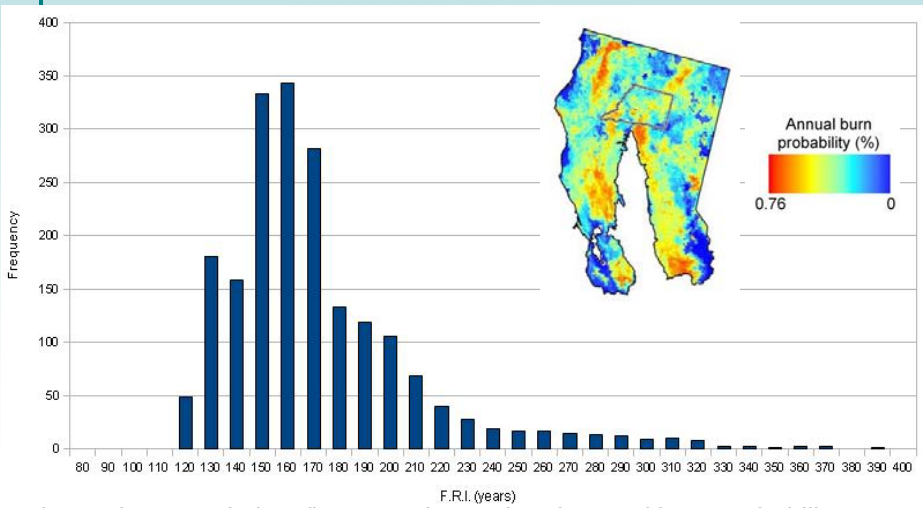
Ct	C stocks remaining in the forest after treatment and no wildfire
Cw	carbon stored as wood products
Ce	reduced emissions from using biomass for energy generation
Cb	carbon stocks in the forest before treatment and no wildfire
risk	probability of fire
Ctf	C stocks remaining in the forest after treatment plus wildfire
Cbf	C stocks remaining in the forest before treatment plus wildfire

Effects of fuel treatment on forest carbon stocks

Estimates of carbon stocks in t C/ac for above and below ground biomass of trees, dead wood, forest floor, and non-tree biomass

		Pre-Treatment	Post-Treatment
Oregon	Bull (Fremont)	82	72
	Collins	55	34
California	Davis	51	48
	HH	64	55
	Berry (PG&E)	70	51

Shasta County Fire Return Intervals



Moritz et al. UC Berkeley; fire return interval and annual burn probability

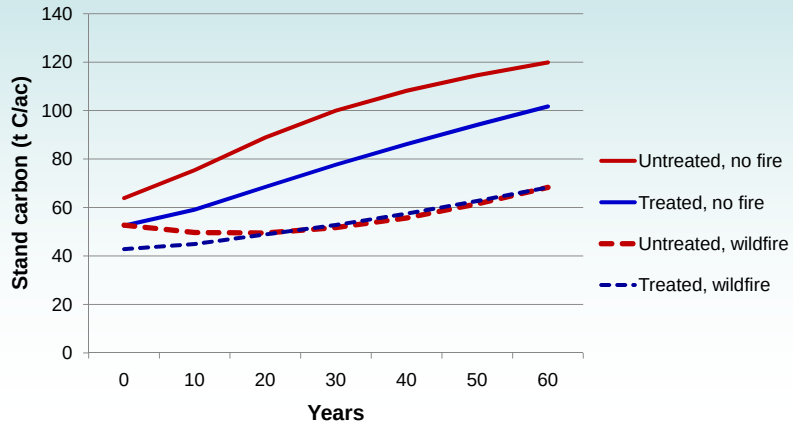
Shasta Co. – HH carbon stocks (t C/ac)

	Pre-Treatment stocks	Post-Treatment stocks, incl. wood products & biomass
Without fire	64	55
With fire	53	45

Net emissions in year one = 8.8 t C/ac
(12,716 t C emitted across 1,445 acres)

Shasta Co. – HH Modeled Growth

Growth modeled over 60 years using the Forest Vegetation Simulator (FVS) to project all scenarios



Fuel Treatments and Forest Growth

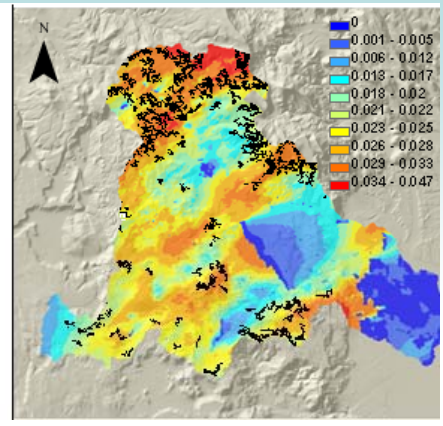
		Fire Emissions in Year One		Net Emissions from Treatment, w/Fire	
		Without Treatment	With Treatment	Short Term (10 yrs)	Long Term (60 yrs)
		t CO_2/ac			
Oregon	Bull	-43	-47	-41	-21
	Collins	-29	-33	-81	-77
California	Davis	-37	-34	-20	-14
	HH	-40	-35	-41	-24
	Berry	-43	-26	-36	+35

Offset Methodology Conclusions

- The annual fire risk does not exceed 0.76% in any of the forest types examined in parts of CA and OR.
- Fuels treatment leads to reductions in stocks of 10 to 40% with corresponding emissions
- Fuels treatments must be conducted across a wide area due to the unpredictability of fire occurrence
- From a GHG perspective, the net effect of removing hazardous fuels in Southern Oregon and California is an increase in emissions

ArcFuels* Simulation of Fuel Treatments Wildfire and Carbon Offsets

Alan A. Ager, USDA Forest Service, Western Wildlands Environmental Threat Assessment Center



Conditional Burn Probability Analysis of All Possible $C0_2$ Emission Scenarios Including No Wildfire at a Landscape Scale

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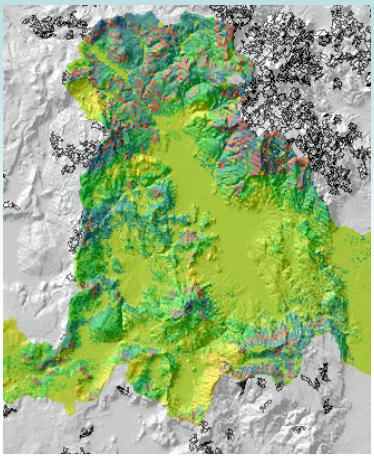
Expected Carbon Offset from Fuel Treatment



Expected Carbon Offset = Expected Carbon Stock Treated Landscape – Expected Stock Untreated Landscape

- Positive Carbon Offset (Benefit)
- Neither Positive or Negative (Neutral)
- Negative Carbon Offset (Loss)

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westcarb.org

Expected Carbon Offset Fuel Treatments - Emissions

Emission Source	Treated Landscape	Untreated Landscape	Difference
	--- short tons carbon ---		
Merchantable Material Removed from Treatment	-41,884	0	-41,884
Non-Merchantable Material Removed from Treatment	-62,796	0	-62,796
Prescribed Fire in Treatments	-111,893	0	-111,893
Wildfire Treated Stands	-157	-3,857	3,700
Wildfire Non-Treated Stands	-8,936	-12,023	3,087
		OFFSET	-209,786

Loss – CO_2 Emissions from Treatments

Benefit - Expected Avoided CO_2 Emissions from Wildfire

Carbon Offset Market Validation

Peter Kelly, The Climate Trust

Fuel Treatment Projects Face Many Challenges in Meeting Quality Offset Initiative Criteria

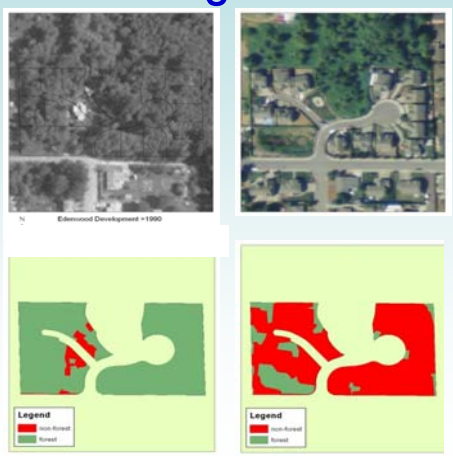
- **Certainty of avoided emission "event" in baseline means project life = 1/(Annual Probability of "Problem" Wildfire)**
- **The "project" is a commitment to a schedule of fuel treatment practices applied repeatedly over time on the landscape (analogous to an Improved Forest Management Project)**
- **Depending upon fuel treatment "shelf life," fuel treatments may or may not recoup initial carbon losses from treatment through avoided emissions from wildfire.**

WESTCARB Regional Characterization: Washington State

- Opportunity to create mechanisms to generate offsets from urban development in the Puget Sound Region
  - Relationship between the total area of development and the percentage of original carbon stocks remaining post development
  - Credits could be generated when business-as-usual scenario for forest retention is exceeded
  - More research is needed to develop performance standard that defines emissions relative to unit of production

One acre lots in Snohomish County immediately following site clearing and post-construction

WESTCARB Regional Characterization: Washington State



Residential subdivision in King County before development (circa 1990) and after development in 2009

- Characterization of the GHG emissions associated with conversion of forest to residential development in the Puget Sound Region
  - Identification of residential zones with highest levels of development in King, Pierce, and Snohomish Counties
  - Spatial analysis of deforestation and estimation of emissions from forest conversion
  - Measurement of carbon stocks on developed lands and estimation of carbon sequestration post-development
  - Full accounting of development emissions

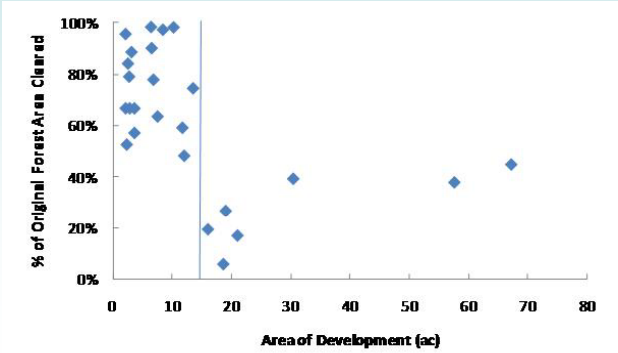
WESTCARB Regional Characterization: Washington State

- Summary of results from spatial analysis of change in forest cover associated with development:

County	Zone	Minimum Lot Size (ac)	Mean Total Development Area (ac)	Initial Forest Cover (%)	Deforestation (%)
King	R4	0.25	2.94	76%	57%
Pierce	MSF	0.17	5.95	89%	86%
Snohomish	R9600	0.22	7.94	55%	69%
Snohomish	R5	1.00*	29.76	91%	32%

WESTCARB Regional Characterization: Washington State

- The percent of original forest area cleared was related to the total area of development



WESTCARB Regional Characterization: Washington State

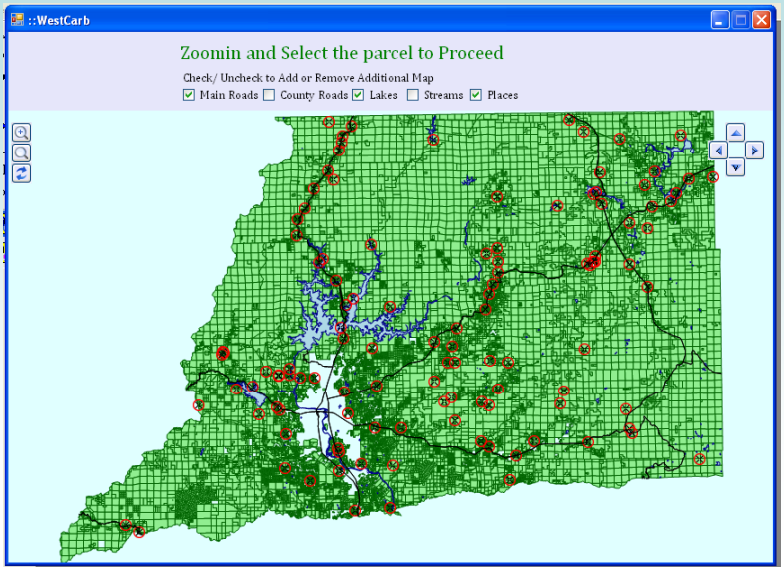
- Net greenhouse gas emission/sequestration from urban development at five sites in King County expressed in t CO_2-e
- Development emission is sum of emissions from harvested wood products plus energy recovery emissions

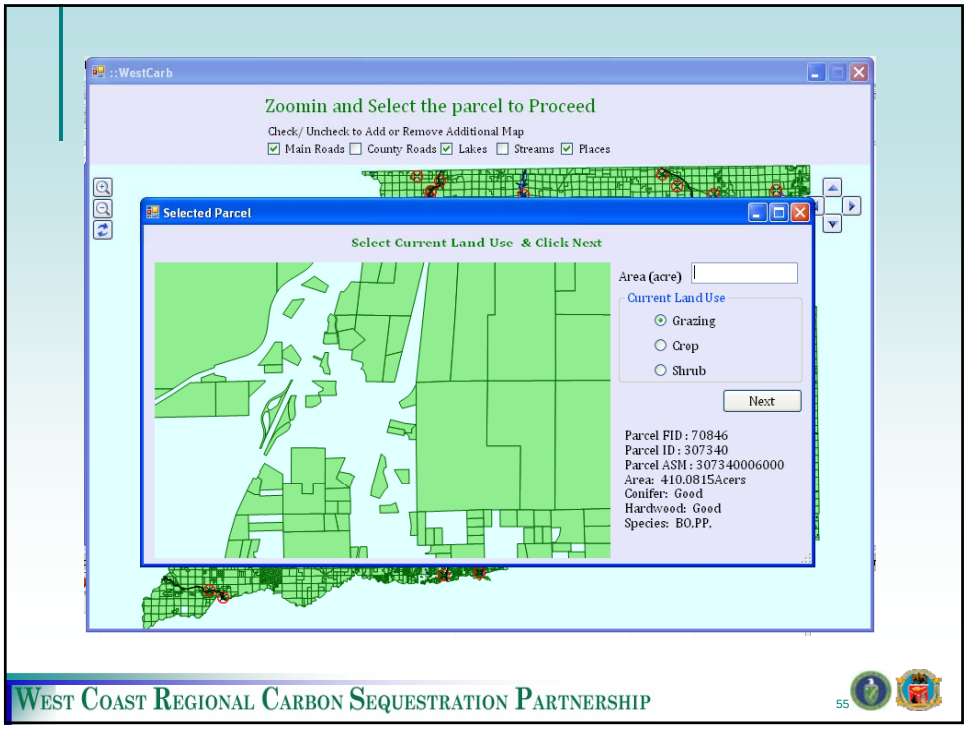
	Zone	Total Dev. (ac)	Number of Built Lots	Average Size of Built Lots (ac)	Built Lots as a Proportion of Total Area	Development Emission	Carbon Stock Recovery	Net Emission
Canterberry Crossing	R4	3.2	20	0.12	75%	265	110	155
Edenwood	R4	2.6	15	0.16	95%	242	102	140
Evetts Park	R4	3.7	10	0.35	93%	223	124	99
Hidden Tree	R4	2.8	19	0.12	83%	114	105	9
Norway Knoll	R4	2.4	20	0.12	100%	124	109	15

ONLINE LANDOWNER TOOL

To assist landowners to make economic assessment of the revenue stream from implementing afforestation/reforestation projects

Outreach – Online A/R Tool




::WestCarb
Zoomin and Select the parcel to Proceed
Check/ Uncheck to Add or Remove Additional Map
Main Roads
County Roads
Lakes
Streams
Places
Selected Parcel
Select Current Land Use & Click Next
Area (acre)
Current Land Use
Grazing
Crop
Shrub
Next
Parcel FID : 70846
Parcel ID : 307340
Parcel ASM : 307340006000
Area: 410.0815Acers
Conifer: Good
Hardwood: Good
Species: BO,PP,
WEST COAST REGIONAL CARBON SEQUESTRATION PARTNERSHIP
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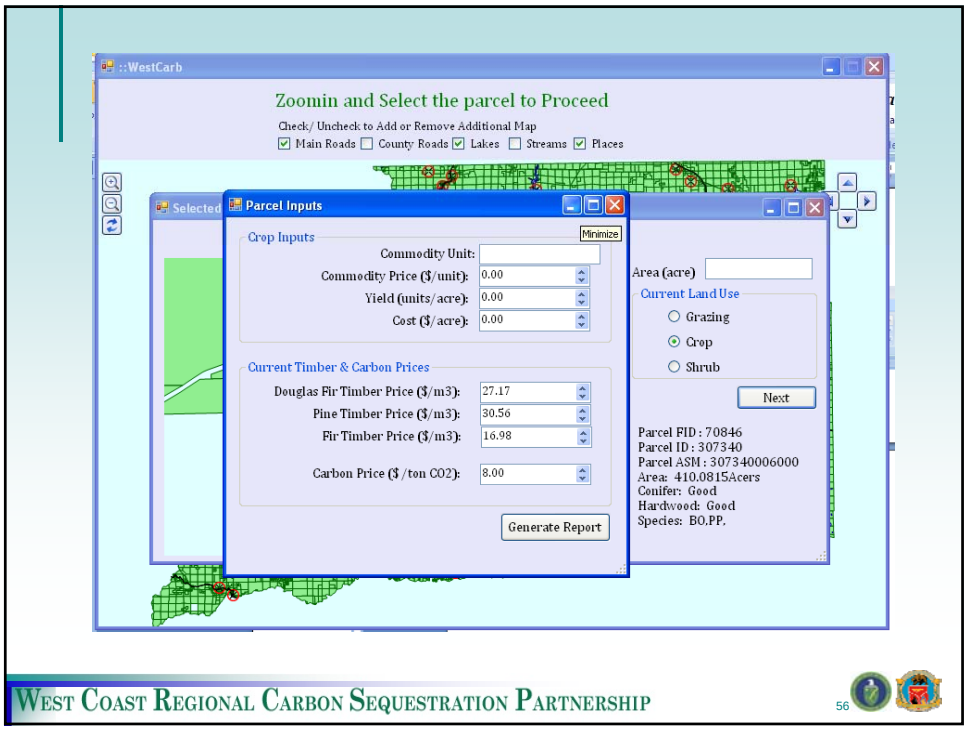
::WestCarb
Zoomin and Select the parcel to Proceed
Check/ Uncheck to Add or Remove Additional Map
Main Roads
County Roads
Lakes
Streams
Places
Parcel Inputs
Minimize
Crop Inputs
Commodity Unit:
Commodity Price ($/unit):
0.00
Yield (units/acre):
0.00
Cost ($/acre):
0.00
Current Timber & Carbon Prices
Douglas Fir Timber Price ($/m3):
27.17
Pine Timber Price ($/m3):
30.56
Fir Timber Price ($/m3):
16.98
Carbon Price ($/ton CO2):
8.00
Generate Report
Area (acre)
Current Land Use
Grazing
Crop
Shrub
Next
Parcel FID : 70846
Parcel ID : 307340
Parcel ASM : 307340006000
Area: 410.0815Acers
Conifer: Good
Hardwood: Good
Species: BO,PP,
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Species: Douglas Fir
Year of timber harvest: 50
Projected timber volume: $ 1,480.00
Timber Income: $ 40,211.60

Year	C stored (tonnes)	Offsets Generatede	Project costs	Expected carbon income	Net revenue (income minus costs)
5	180.00	144.00	5,185.00	1,152.00	-4,033.00
10	180.00	144.00	1,225.00	1,152.00	-73.00
15	260.00	208.00	1,225.00	1,664.00	439.00
20	340.00	272.00	1,225.00	2,176.00	951.00
25	680.00	544.00	1,225.00	4,352.00	3,127.00
30	1,010.00	808.00	1,225.00	6,464.00	5,239.00
35	1,560.00	1,248.00	1,225.00	9,984.00	8,759.00
40	2,100.00	1,680.00	1,225.00	13,440.00	12,215.00
45	2,640.00	2,112.00	1,225.00	16,896.00	15,671.00
50	2,640.00	2,112.00	3,691.00	16,896.00	13,205.00

Total potential project income(timber income plus net revenue at year of timber harvest): **$ 53,416.60**

Contact info

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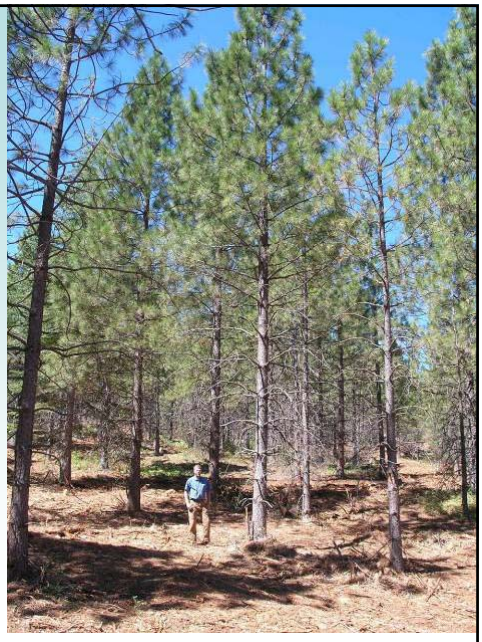
Follow up management recommendations now that WESTCARB II Projects are successfully forested & funding has ended:

Fall 2010: stocking and competing vegetation surveys conducted by Beaty foresters w/ recommendations for future management prepared by Beaty RPF/PCA.

- *Control of competing forbs & grasses in 2011 within 5 feet of conifer seedlings is still important for a few projects (1 & 2 yr old seedlings on projects w/ shallow soils w/ low AWC & grasses present).*
- *Monitoring & management of brush is important for next 3 to 5 years on all projects to maintain forest growth & health.*
- *Monitoring & management of stocking (tree density) is important for the next several decades on all projects to maintain long term forest growth and health (& live carbon storage)*

Landowners must also manage tree stocking/spacing for the next several decades to keep forest plantation growing well & healthy & to increase resiliency to wildfire

28 year old pine plantation near Whitmore after pre-commercial biomass thin to reduce stocking to more "natural" levels & maintain tree vigor, growth & reduce risk of mortality from insects & wildfire.



5-year Growth Increments

Plantation that was planted @ 300 trees per acre and not thinned.

Very good growth for the first 15 years then increasingly slower growth & declining vigor due to increasing inter-tree competition.

Elliot Ranch Plantation/ Levels of Growing Stock Studies Re-measured in 2009

Results: Ponderosa pine stocking levels must be managed to reduce significant mortality from bark beetles.

Typical of plots w/ highest SDI

Challenge Experimental Forest

42 year old pond pine planted @ 6' x 6' spacing: low vigor, QMD = 6.5"

Challenge Experimental Forest

42 year old pond pine planted @ 18' x 18' spacing: vigorous, QMD = 16.0"


Managed mature forest
= High carbon storage
+ resilient to fire
89 year-old Show Plantation