Estimating the Greenhouse Gas Reductions of Reforestation Projects

Richard Harris, Ph.D, RPF 1961
Consultant to Nor Cal SAF

What is “Business as Usual”?

- FIA indicates that there are over 8 million acres of un-stocked or poorly stocked forestland in California, including nearly 2 million acres of mixed conifer and ponderosa pine types.
- The Forest Practice Act does not require reforestation of “substantially damaged timberland” (14 CCR 1080(a)(2)) unless live trees were harvested.
- Conversion of forest types to brush fields has carbon consequences (Hugh Safford)
- Costs for reforestation can be prohibitive even if salvage logging is conducted

GHG Analysis Process

- Characterize site conditions
  - Carbon loading
  - Site class
  - Vegetation type
- What is the prescription?
  - Species, seed zone, seedling source(s)
  - Stocking

Process (cont.)

- What site preparation methods will be used?
  - Disposition of existing biomass
  - Disturbance
  - Estimate emissions from equipment
- Projection of future forest
  - Based on COLE and FIA plots
  - Based on inventory data and modeling
  - Other methods

Process (cont.)

- Estimate greenhouse gas reductions
  - Subtract emissions from biomass disposed of on-site and equipment operations from future projected carbon stocks
  - Convert to greenhouse gas quantities in tonnes of CO2/acre
- Adaptive management
  - Adjust prescription, emissions sources etc. to achieve desired reductions

Data Acquisition

- Existing carbon loading
  - Transects i.e., Brown's planar intercept method
  - Photographic keys
    - RMRS_GTR-153 for grass and shrub types
    - GTR PNW-95 for mixed conifer
- Site class and vegetation type
  - Site class derived from NRCS soils maps or other sources
  - Vegetation types correspond to FIA types

USDA FOREST SERVICE GENERAL TECHNICAL REPORT PNW-95
OCTOBER 1979

PHOTO SERIES FOR QUANTIFYING FOREST RESIDUES IN THE:

SIERRA MIXED CONIFER TYPE
SIERRA TRUE FIR TYPE

WAYNE G. MAXWELL
FRANKLIN R. WARD

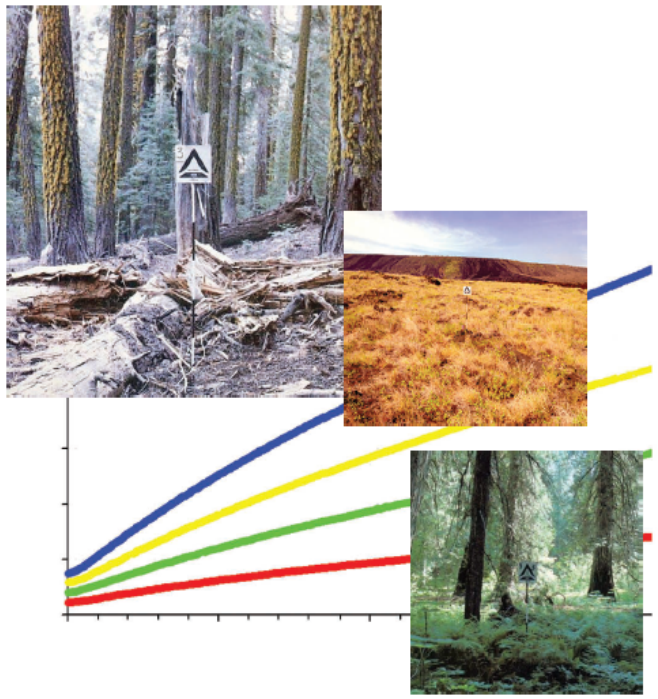
COSPONSORED BY: PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION
AND PACIFIC SOUTHWEST FOREST AND RANGE EXPERIMENT STATION

PUBLISHED BY: PACIFIC NORTHWEST FOREST AND RANGE EXPERIEMENT STATION
U.S. DEPARTMENT OF AGRICULTURE FOREST SERVICE

USDA United States Department of Agriculture
Forest Service
Rocky Mountain Research Station
General Technical Report RMRS-GTR-153
June 2005

Standard Fire Behavior Fuel Models: A Comprehensive Set for Use with Rothermel's Surface Fire Spread Model

Joe H. Scott
Robert E. Burgan



United States Department of Agriculture

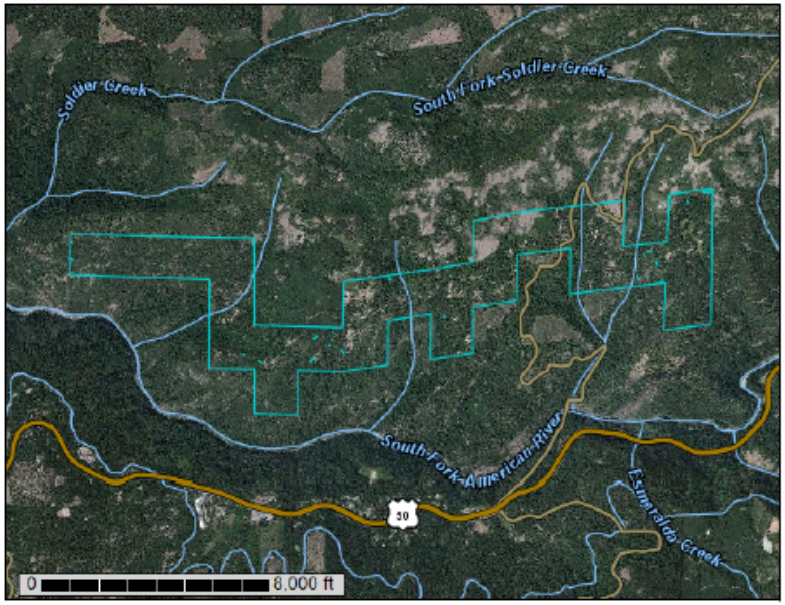
NRCS

Natural Resources Conservation Service

A product of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other Federal agencies, State agencies including the Agricultural Experiment Stations, and local participants

Custom Soil Resource Report for Eldorado National Forest Area, California, Parts of Alpine, Amador, El Dorado, and Placer Counties

King Fire Private Parcels (South) Soils Report



California's Forest Resources: Forest Inventory and Analysis, 2001-2010

Glenn A. Christensen, Karen Waddell, Sharon Stanton, and Olaf Kuegler

Contributing Authors:
Joel Thompson, John Chase, Jeremy Fried, Andrew Gray, and Sarah Jovan

U.S. Department of Agriculture, Forest Service

Pacific Northwest Research Station

Portland, Oregon

General Technical Report PNW-GTR-XXX

Month year

Prescription and Site Preparation

- Species, stocking, seed zone, seedling source determined by RPF in consultation with nursery
- Site preparation
  - Is woody biomass involved?
  - Will site preparation involve soil disturbance?
  - Equipment emissions: Equation 6.2 from ARB forest protocol

Site Preparation Emissions

Heavy- 50% or more of the project area is covered with brush and removed as part of site preparation or stumps are removed (mobile emissions estimated at 0.429 metric tonnes CO2e per acre, biological emissions estimated at 2 metric tonnes CO2e per acre)

Medium - >25% <50% of the project area is covered with brush and removed as part of site preparation (mobile emissions estimated at 0.202 metric tonnes CO2e per acre, biological emissions estimated at 1 metric tonne per acre).

Light - 25% or less of the project area is covered with brush and is removed as part of site preparation (mobile emissions estimated at 0.09 metric tonnes CO2e per acre, biological emissions estimated at 0.5 metric tonnes per acre).

None - No site preparation is conducted.

Projection of Future Forest

- Forest Carbon On-line Estimator based on FIA data
- Stand development modeling with FVS, FORSEE or other tool
- Validation
  - FIA data can be used to validate estimates (demonstrated below)
  - Modeling may also be used for comparison to estimates

Forest Vegetation Simulator

- For ponderosa pine and mixed conifer, refer to Oliver, W.W. and R.F. Powers. 1978. Res. Paper PSW-133 for information on early stand development.
- Also see Hoover, C.M. and S.A. Rebain. 2011. Gen. Tech. Rep. NRS-77 for "seven things you need to know using FVS for forest carbon estimates".
- Output:

****** CARBON REPORT VERSION 1.0 ******
STAND CARBON REPORT (BASED ON STOCKABLE AREA)
ALL VARIABLES ARE REPORTED IN METRIC TONS/ACRE

STAND ID: 01 MGMT ID: NONE

	Aboveground Live		Belowground		Stand	Forest			Total Stand	Total Removed	Carbon Released
YEAR	Total	Merch	Live	Dead	Dead	DDW	Floor	Shb/Hrb	Carbon	Carbon	from Fire
2055	66.6	46.6	15.9	0.0	0.0	8.2	5.2	0.2	96.1	0.0	0.0
2065	71.4	51.7	15.9	4.2	17.2	7.6	5.9	0.2	122.4	0.0	0.0
2075	80.1	60.0	16.9	5.5	19.0	16.7	5.6	0.2	144.0	0.0	0.0
2085	84.5	65.1	17.6	6.3	19.6	25.5	5.6	0.2	159.4	0.0	0.0
2095	89.9	70.3	18.6	6.4	19.9	31.0	5.5	0.2	171.5	0.0	0.0
2105	93.0	74.6	19.5	6.3	20.8	34.4	5.5	0.2	179.8	0.0	0.0
2115	94.4	77.4	20.4	6.1	21.8	36.4	5.5	0.2	184.8	0.0	0.0
2125	95.4	79.2	21.3	5.9	22.8	37.3	5.4	0.2	188.2	0.0	0.0
2135	95.8	80.8	22.1	5.6	23.7	37.4	5.4	0.2	190.2	0.0	0.0
2145	96.0	81.7	22.8	5.3	24.2	36.9	5.4	0.2	190.8	0.0	0.0

Estimate Net GHG Reductions

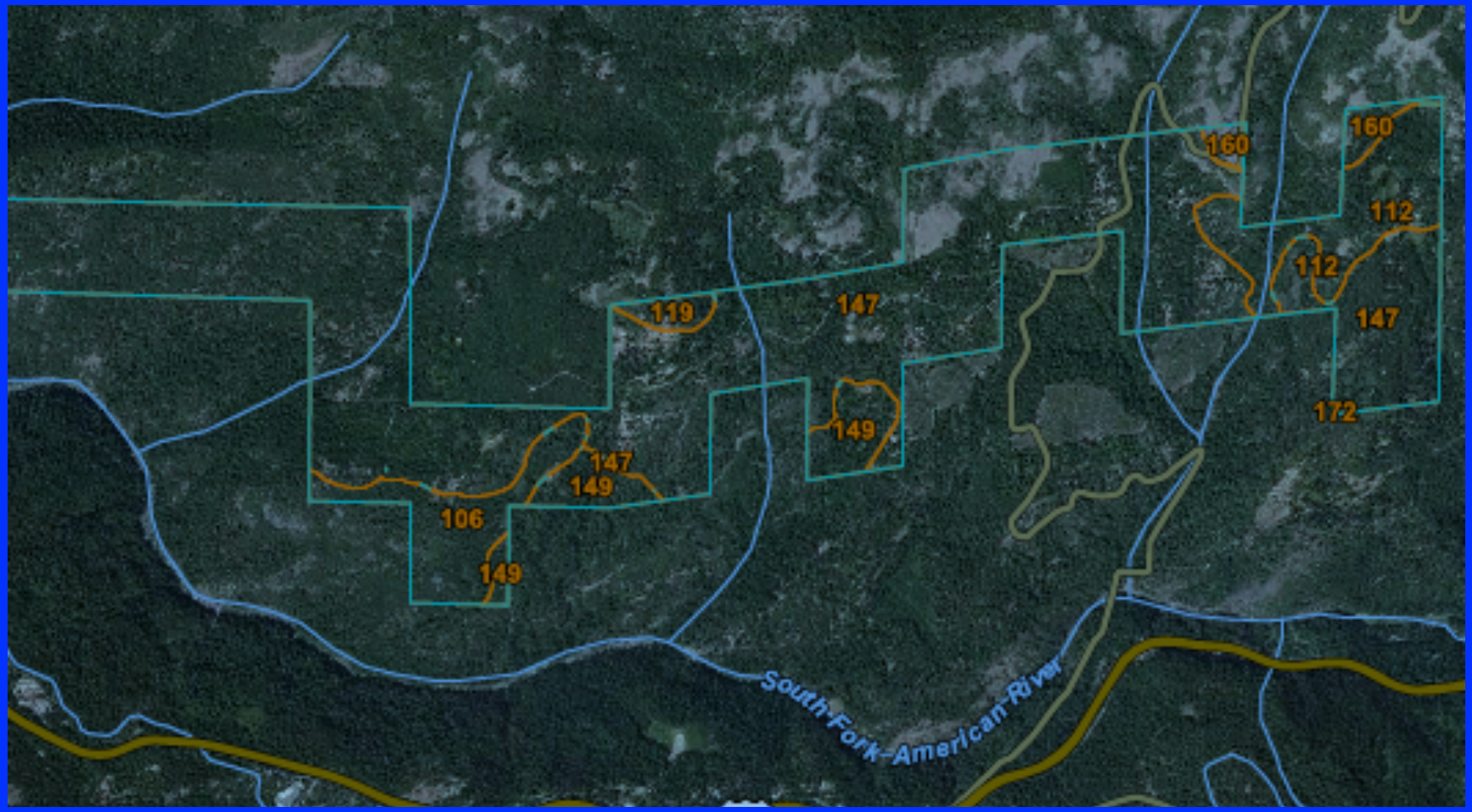
- Subtract emissions from carbon accrual to determine net GHG reductions
- What if net GHG reductions are negative or 0?
  - Consider ways to reduce emissions
  - Consider restricting reforestation to the highest site classes
  - Explore opportunities for utilization of biomass


Example: watershed reforestation at the King Fire, El Dorado County

Existing Conditions

- Project area is 1500 acres with nearly total mortality (total area of fire >97,000 acres)
- Sites have been salvaged and site prepped, salvaged with no site prep or untreated.
  - Area to be reforested: 1300 acres
  - Existing biomass: 10, 40 and 130 tons/acre, depending on post-fire management
  - Total estimated pre-treatment CO2: 86,300 tonnes

Soils and Site Productivity



Site Class versus Site Productivity

Site Class based on tree height at a base age is used in FVS modeling and NRCS. FIA productivity classes are used in COLE. Apples and oranges?

Min height @ 100 yrs (ft))		MCN(yg)	DFR	RDW
200	Timberland	I	I	I
180	Timberland	I	II	I
160	Timberland	I	III	II
140	Timberland	I	III	III
120	Timberland	I	IV	IV
100	Timber/Non-	II	V	V
80	Non-/Timber	III	V	V
60	Non-/Timber	IV	V	V
40	Non-timberland	V	V	V

Site Productivity Classes (FIA)				CAL FIRE	
SITECLCD	(ft3/acre/yr)	USFS Land Use	MCN	DFR	RDW
1	225+	Timberland	I	-	I
2	195 - 224	Timberland	II	I	II
2.5	165 - 194	Timberland	II	II	II
3	120 - 164	Timberland	III	III	III
4	102 - 119	Timberland	IV	IV	IV
4.5	85 - 102	Timberland	IV	IV	V
5	50 - 84	Timberland	V	V	V
6	20 - 49	Timberland	V	V	V
7	0 - 19	Other forest land	V	V	V

According to NRCS and local data, the project area is Site Class I. According to FIA productivity criteria Site Class is II or III.

Results from COLE

Table 1: **Carbon Stocks by Age Class for California**

Age Class	Mean volume	Live tree	Dead tree	Under story	Down dead wood	Forest floor	Soil	Total non soil
years	m^3/hectare	tonnes carbon/hectare						
0	0	0	0	0	19.61	36.25	49.8	55.86
5	0.7	0.31	0	3.97	19.61	36.25	49.8	60.14
10	4.8	2.07	0.01	7.66	19.61	36.25	49.8	65.6
15	13.94	5.92	0.04	6.66	19.61	36.25	49.8	68.47
20	28.5	11.92	0.08	5.37	19.61	36.25	49.8	73.22
25	48.14	19.84	0.15	4.43	19.61	36.25	49.8	80.29
30	72.13	29.32	0.26	3.78	19.61	36.25	49.8	89.22
35	99.59	39.96	0.4	3.32	19.61	36.25	49.8	99.53
40	129.6	51.36	0.57	2.97	19.61	36.25	49.8	110.76
50	193.91	75.08	1.06	2.51	19.61	36.25	49.8	134.51
60	259.41	98.35	1.72	2.23	19.61	36.25	49.8	158.15
70	322.18	119.86	2.56	2.04	19.61	36.25	49.8	180.32
80	379.89	138.97	3.61	1.9	19.61	36.25	49.8	200.33
90	431.42	155.46	4.84	1.81	19.61	36.25	49.8	217.97
100	476.45	169.42	6.25	1.74	19.61	36.25	49.8	233.27
a	704.09	230.2	152.46					
b	0.02	0.02	0					
se	390.77	137.94	12.55					
n	28							

Analysis based on COLE

- Total CO2 storage at 100 years
  - Live trees and dead trees @ 100 years: roughly 260 tonnes/acre
  - Total estimated live and dead tree CO2 for project area = 338,000 tonnes
- Total CO2 storage at 50 years = 143,000 tonnes

Analysis (cont.)

- Emissions from equipment: 0.429 tonnes CO2/acre x 1300 treated acres = about 600 tonnes
- Emissions from slash disposal: about 86,300 tonnes (assumes pile and burn)
- Total emissions: 86,900 tonnes
- Net GHG reductions: 143,000 tonnes at 100 years or 56,100 tonnes at 50 years

Validation

- FIA data analysis
  - Average CO2 storage for mixed conifer across all site classes and ages at full stocking: 203 tonnes/acre
  - CO2 storage by site class of live trees at full stocking varies from 199-321 tonnes/acre

Site Class	Acres	Total Carbon Storage (tonnes)	Average Carbon Storage (tonnes/acre)	Average CO2 Storage (tonnes/acre)
1	21,324	1,864,453	87	321
2	305,408	18,936,423	62	228
3	1,041,628	64,039,776	61	226
4	1,099,173	59,732,658	54	199

Validation (cont.)

Results of FVS plantation modeling

****** CARBON REPORT VERSION 1.0 ******
STAND CARBON REPORT (BASED ON STOCKABLE AREA)
ALL VARIABLES ARE REPORTED IN METRIC TONS/ACRE

STAND ID: 01 MGMT ID: NONE

	Aboveground Live		Belowground			Forest			Total	Total	Carbon
					Stand				Stand	Removed	Released
YEAR	Total	Merch	Live	Dead	Dead	DDW	Floor	Shb/Hrb	Carbon	Carbon	from Fire
2055	66.6	46.6	15.9	0.0	0.0	8.2	5.2	0.2	96.1	0.0	0.0
2065	71.4	51.7	15.9	4.2	17.2	7.6	5.9	0.2	122.4	0.0	0.0
2075	80.1	60.0	16.9	5.5	19.0	16.7	5.6	0.2	144.0	0.0	0.0
2085	84.5	65.1	17.6	6.3	19.6	25.5	5.6	0.2	159.4	0.0	0.0
2095	89.9	70.3	18.6	6.4	19.9	31.0	5.5	0.2	171.5	0.0	0.0
2105	93.0	74.6	19.5	6.3	20.8	34.4	5.5	0.2	179.8	0.0	0.0
2115	94.4	77.4	20.4	6.1	21.8	36.4	5.5	0.2	184.8	0.0	0.0
2125	95.4	79.2	21.3	5.9	22.8	37.3	5.4	0.2	188.2	0.0	0.0
2135	95.8	80.8	22.1	5.6	23.7	37.4	5.4	0.2	190.2	0.0	0.0
2145	96.0	81.7	22.8	5.3	24.2	36.9	5.4	0.2	190.8	0.0	0.0

Predicted CO_2 storage at 50 and 100 years exceeds storage predicted by COLE but compares favorably with average storage on high sites according to FIA.

Some Issues

- Disposition of materials removed during site preparation has an impact on projections.
- Some methods of site preparation e.g., deep ripping may have benefits. The associated emissions should be considered.
- Site Class according to COLE/FIA may not correspond to Site Class derived from other sources.
- COLE can only use plots within a specified radius from the project area to estimate carbon storage.
- COLE estimates have associated standard errors that must be considered in evaluating the results.

Discussion

- Net GHG reductions = 56,100 or 251,000 tonnes
- Other considerations
  - Assurances
  - Utilization
  - Future management and harvesting
- Monitoring
  - During implementation
  - Post-implementation
  - Stocking surveys

Questions?