Demography of Snags in Eastside Pine Forests of California[1]

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Abstract

Nine years of annual observations of snags on 24, 5-hectare plots in northeast California were analyzed. *Pinus ponderosa, Pinus jeffreyi*, and *Abies concolor* were the most abundant tree species. The rate and timing of snag creation varied between species. Of the snags standing at the end of the observation period, 88 percent retained their original height; 6 percent of the *Pinus jeffreyi* and 12 percent of the *Abies concolor* were rendered generally unsuitable for cavity nesting birds by height loss; and 13 percent of the *Pinus jeffreyi* and 4 percent of the *Abies concolor* lost bark cover during the observation period. On an annual basis, 7 percent of the pine snags and four percent of the *Abies concolor* snags fell over. The "half life" for snags was 6 years for the pine species and 8 years for *Abies concolor*. Increases in snag fall rate occurred after prescribed fire. The total amount of snags increased during the observation period.

Introduction

The benefits and costs of snags and their derivatives have been well documented (Bull and others 1997, Dudley 1982, Maser and Sedell 1994, Valdez 1996, Weatherspoon and Skinner 1996). However, information about the rates at which snags are created, accumulate, decay, and ultimately fall down is scant. This information is useful when making inferences about habitat quality, productivity, fire hazard, and human safety, all important components of ecosystem health. It is also useful when planning and predicting levels of snags across a landscape through time.

Two major studies of snag dynamics have been reported from California. Keen (1955) summarized 30 years of annual surveys of beetle-killed ponderosa pine *(Pinus ponderosa)* from five 256-ha plots in northeastern California and southern Oregon. That study had the advantage of a relatively long observation period and of knowing when individual trees died, but was limited to pure ponderosa pine killed by one agent. Raphael and Morrison (1987) summarized observations on four species from eight 8.5 hectare plots installed over a 4-year period and re-measured 5 years later on the eastern slope of the Sierra Nevada near Truckee. That study included several agents of tree mortality, several tree species, and some site variation, but was limited

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by a relatively short observation period and by not knowing when individual trees died.

This paper uses data from an ongoing study from annual surveys over a 9-year period from 24, 5-hectare plots within the Modoc Plateau and Southern Cascade ecological sections (McNab and Avers 1994). It includes several agents of mortality, several species, and relatively broad site variation, but is limited by not knowing when snags in the initial observation died and the relatively short observation period to date. Large sample sizes of ponderosa pine (*Pinus ponderosa*, PP), Jeffrey pine (*Pinus jeffreyi*, JP*),* and white fir (*Abies concolo*, WF) are included. Small sample sizes of western juniper (*Juniperus occidentalis*, WJ), lodgepole pine (*Pinus contorta*, LP), incense cedar (*Calocedrus decurrens*, IC), black oak (*Quercus californica*, BO), and red fir (*Abies magnifica*, RF) are included. The silvical characteristics of these species have been documented (Burns and Honkala 1990). Many factors contribute to rates of creation, decay, inventory, and fall, including soil characteristics, topographic position, climate, stand density, incidence of root disease, windstorms, and firestorms, amount of decay before death, time since death, species, diameter, and the proportion of heartwood. The purpose of this paper is to provide information on snag demographics and associated variation with tree species, diameter, time since death, and fire history, for improving predictions of future condition and for planning and implementing landscape and larger scale projects.

Methods

Twenty-four sites were selected from a pool of about 2,000 mapped polygons, segmented into six density classes. Each site is 5 hectares in size (500m by 100m). The sites were established at selected locations in 1988 and 1989.

Site Characteristics

The sites are within either the Modoc Plateau or Southern Cascade ecological sections on either the Modoc National Forest, the Lassen National Forest, the Blacks Mountain Experimental Forest, or the Lassen Volcanic National Park.

These sites are characterized by long dry summers. Mean annual temperature ranges from 7 to 11 ºC. Mean annual precipitation ranges from 300 to 760 mm. *Table 1* summarizes site characteristics. These sites exist across a range of temperature and moisture. Some sites (Baseball, Four-mile, Pease Cabin, Pease Flat) only support ponderosa pine and western juniper. They are relatively warm-dry sites. Other sites (Butte Lk 1, Butte Lk 2, Lost Creek 3) support red fir. They are relatively cold-moist sites. Still others (Bieber, Pit River) support California black oak. They are relatively warm-moist sites. Most sites are relatively cool and moist and support Jeffrey pine, ponderosa pine, and white fir in some combination. White fir exists on the edge of its range in some of these sites as limited by available water and is relatively more abundant now than earlier in the century.

Over the 9-year period of observation wildfire, prescribed fire, harvest, or some combination of the three have occurred on some, but not on most, sites *(table 1).*

Table 1—*Numbers of snags on each of the 24, 5-ha study sites.*

Site	Wildfire	Rx Fire	Harvest	JP	PP	WF	WJ	LP	IC	BO	RF	Total[1]
Ashurst				9	37	67						113
Baseball					66		12					78
Bieber				17	1		2		2	6		28
BM34/125		Fall 1997	1996	1	52							53
BM34/151b			1997	36	55	215						306
BM34/151				73	93	63						229
BM34/75		Fall 1997	1996	10	55							65
BM34/ Roseburg		Fall 1997		41	106	68						215
BM34/Snags		Fall 1997	1996	8	59							67
BM34/ Squirrel			1997	61	47	109			4			221
BM35/88			1996	118	48	53			5			224
Butte Lk 1		1990 & 1995		155	32	47					1	235
Butte Lk 2				128	13	20					4	165
Butte Lk 4				220		9		35				264
Four-mile					133		39					172
Lost Creek 1		Spring 1999		150	3	3		15			2	173
Lost Creek 3				458		11						469
N Mud Lake	1996			1	13							14
Pease Cabin					17		4					21
Pease Flat					125		8					133
Pit River				18	18	265	4		32	2		339
Soup Creek				65	3	9	1					78
S Mud Lake				6	20		14					40
Whitehorse				24	3	5						32
Grand Total				1,599	999	944	84	50	43	8	7	3,734

[1] These snag counts reflect total individual snags that have been observed. The counts disclosed elsewhere will not match these totals for various reasons. Twenty snags have no recorded diameters; 90 snags were consumed or felled by fire; 349 snags were harvested; 13 snags on the Baseball site have been topped at 30 or 40 feet to lower the risk of blow-down and promote decay from the top. Individual snags come into and out of analysis depending on the question being examined.

Data Collection

All snags present in the year of establishment were mapped and individually marked. Trees were considered snags when all needles were dead. Jeffrey pine and ponderosa pine snags were often hard to distinguish in the field. Species, diameter, height, and percent bark cover on the bole were recorded. Year of death for these snags is not known. Sites have been resampled with the same protocol each year since establishment. New snags were added to the record (year of death is known). Status of previously measured snags (standing or down), new height, new percent bark cover, and effects of fire or cutting were recorded.

Analysis

Creation Rates

Creation rates were established for Jeffrey pine, ponderosa pine, and white fir by tallying the number of snags that entered the study in each of the years 1990 through 1998 *(table 2)*. To compare the patterns of drought and snag creation, annual averages of monthly values for the Palmer Drought Severity Index were compiled from National Climatic Data Center's State Division 2 data, which includes the Sacramento Valley and Modoc Plateau.

Table 2—*Percent and count by year of snags still standing since death.*

Year of death	Years since death								
	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Ponderosa pine	**Percent of snags still standing, by years since death**								
1990	100	97	97	90	82	66	53	50	48
1991	100	98	92	80	61	46	43	39	
1992	100	96	91	80	54	48	46		
1993	100	100	91	72	67	60			
1994	100	100	92	86	83				
1995	100	98	93	86					
1996	100	98	95						
1997	100	94							
Average		98	93	83	69	55	47	45	48
Keen's Avg		100	97	93	89	85	73	58	50
Ponderosa pine	**Count of snags still standing, by years since death**								
1990	62	60	60	56	51	41	33	31	30
1991	61	60	56	49	37	28	26	24	
1992	82	79	75	66	44	39	38		
1993	58	58	53	42	39	35			
1994	36	36	33	31	30				
1995	43	42	40	37					
1996	57	56	54						
1997	34	32							
1998	10								
Jeffrey pine	**Count of snags, by years since death**								
1990	49	48	45	36	33	26	18	17	18
1991	50	49	45	41	38	29	23	23	
1992	33	32	32	28	27	27	22		
1993	91	88	81	73	70	65			
1994	131	128	117	108	104				
1995	216	209	201	197					
1996	138	137	133						
1997	94	94							
1998	17								

(*table 2* continued)

Year of death	Years since death								
	0	1	2	3	4	5	6	7	8
White fir	**Count of snags, by years since death**								
1990	20	17	17	11	11	10	7	7	9
1991	36	36	36	34	30	28	28	32	
1992	39	39	39	39	37	33	35		
1993	89	89	88	88	86	80			
1994	56	55	55	54	54				
1995	256	251	241	227					
1996	76	72	71						
1997	32	31							
1998	43								

Inventory

Inventory equals initial count plus creation minus fall. The inventory of snags through time was calculated for each of four diameter classes (13 + cm, 13-36 cm, 38-74 cm, and 76 + cm diameter at breast height) for Jeffrey pine, ponderosa pine, and white fir.

Decay Rates

Decay rates were inferred from reductions in percent bark cover and height.

Fall Rates

Fall rates were calculated three ways. First, a value was obtained for each year of observation by dividing the number of fallen snags by the total at the beginning of the year, then those yearly values were averaged over the years of observation. We call this the average annual fall rate. Source data for this calculation is provided in *table 3*. The equation is

$$\frac{\sum\left(\frac{Number\ Falling_i}{Number\ at\ Beginning_i} X100\right)}{n}$$

in which:

i = population based on observation year
n = number of populations

Table 3—*Average annual snag fall rates by species and diameters.*

Year	1989	1990	1991	1992	1993	1994	1995	1996	1997
	Jeffrey pine–all diameters								
Initial count	657	698	692	699	711	787	929	984	1,023
Number that fell	8	56	26	79	55	84	83	57	38
Fall rate for the year	1.2 pct	8.0 pct	3.8 pct	11.3 pct	7.7 pct	10.7 pct	8.9 pct	5.8 pct	3.7 pct
Avg. annual fall rate	6.8 pct								
	Jeffrey pine–13-36 cm								
Initial count	335	363	347	350	338	364	423	455	472
Number that fell	5	41	13	47	35	54	51	34	21
Fall rate for the year	1.5 pct	11.3 pct	3.7 pct	13.4 pct	10.4 pct	14.8 pct	12.1 pct	7.5 pct	4.4 pct
Avg. annual fall rate	8.8 pct								
	Jeffrey pine–38-74 cm								
Initial count	224	234	242	239	254	288	338	365	384
Number that fell	3	14	9	22	17	16	23	19	17
Fall rate for the year	1.3 pct	6.0 pct	3.7 pct	9.2 pct	6.7 pct	5.6 pct	6.8 pct	5.2 pct	4.4 pct
Avg. annual fall rate	5.4 pct								
	Jeffrey pine–76+ cm								
Initial count	98	101	103	110	116	132	165	162	164
Number that fell	0	1	4	10	3	4	8	4	0
Fall rate for the year	0.0 pct	1.0 pct	3.9 pct	9.1 pct	2.6 pct	3.0 pct	4.8 pct	2.5 pct	0.0 pct
Avg. annual fall rate	3.0 pct								
	Ponderosa pine–all diameters								
Initial count	411	467	510	575	600	579	555	531	528
Number that fell	6	18	17	33	57	67	81	37	26
Fall rate for the year	1.5 pct	3.9 pct	3.3 pct	5.7 pct	9.5 pct	11.6 pct	14.6 pct	7.0 pct	4.9 pct
Avg. annual fall rate	6.9 pct								
	Ponderosa pine–13-36 cm								
Initial count	161	183	201	244	250	222	207	198	201
Number that fell	2	11	11	23	36	47	46	18	17
Fall rate for the year	1.2 pct	6.0 pct	5.5 pct	9.4 pct	14.4 pct	21.2 pct	22.2 pct	9.1 pct	8.5 pct
Avg. annual fall rate	10.8 pct								
	Ponderosa pine–38-74 cm								
Initial count	131	150	163	171	185	199	191	183	184
Number that fell	1	5	4	6	8	13	21	8	7
Fall rate for the year	0.8 pct	3.3 pct	2.5 pct	3.5 pct	4.3 pct	6.5 pct	11.0 pct	4.4 pct	3.8 pct
Avg. annual fall rate	4.5 pct								
	Ponderosa pine–76+ cm								
Initial count	118	133	145	159	165	158	156	149	142
Number that fell	3	2	2	3	13	7	14	11	2
Fall rate for the year	2.5 pct	1.5 pct	1.4 pct	1.9 pct	7.9 pct	4.4 pct	9.0 pct	7.4 pct	1.4 pct
Avg. annual fall rate	4.2 pct								
	White fir–all diameters								
Initial count	142	161	193	226	299	345	580	636	645
Number that fell	1	4	6	16	10	21	21	23	19
Fall rate for the year	0.7 pct	2.5 pct	3.1 pct	7.1 pct	3.3 pct	6.1 pct	3.6 pct	3.6 pct	2.9 pct
Avg. annual fall rate	3.7 pct								

(*table 3* continued)

Year	1989	1990	1991	1992	1993	1994	1995	1996	1997
	White fir–13-36 cm								
Initial count	48	63	87	105	151	163	370	411	415
Number that fell	0	3	3	10	7	11	17	18	12
Fall rate for the year	0.0 pct	4.8 pct	3.4 pct	9.5 pct	4.6 pct	6.7 pct	4.6 pct	4.4 pct	2.9 pct
Avg. annual fall rate	4.6 pct								
	White fir–38-74 cm								
Initial count	57	62	68	84	110	140	166	181	187
Number that fell	0	1	2	5	3	6	2	4	6
Fall rate for the year	0.0 pct	1.6 pct	2.9 pct	6.0 pct	2.7 pct	4.3 pct	1.2 pct	2.2 pct	3.2 pct
Avg. annual fall rate	2.7 pct								
	White fir–76+ cm								
Initial count	37	36	38	37	38	42	44	44	43
Number that fell	1	0	1	1	0	4	2	1	1
Fall rate for the year	2.7 pct	0.0 pct	2.6 pct	2.7 pct	0.0 pct	9.5 pct	4.5 pct	2.3 pct	2.3 pct
Avg. annual fall rate	3.0 pct								
	Western juniper–all diameters								
Initial count	66	66	69	68	68	69	69	70	69
Number that fell	0	1	2	1	1	2	5	2	0
Fall rate for the year	0.0 pct	1.5 pct	2.9 pct	1.5 pct	1.5 pct	2.9 pct	7.2 pct	2.9 pct	0.0 pct
Avg. annual fall rate	2.3 pct								
	Western juniper–13-36 cm								
Initial count	60	60	61	60	60	61	61	61	60
Number that fell	0	1	2	1	1	2	5	2	0
Fall rate for the year	0.0 pct	1.7 pct	3.3 pct	1.7 pct	1.7 pct	3.3 pct	8.2 pct	3.3 pct	0.0 pct
Avg. annual fall rate	2.6 pct								
	Lodgepole pine–all diameters								
Initial count	30	30	34	38	35	36	34	30	36
Number that fell	0	0	1	4	0	2	4	1	0
Fall rate for the year	0	0	2.9 pct	10.5 pct	0.0 pct	5.6 pct	11.8 pct	3.3 pct	0.0 pct
Avg. annual fall rate	0.0379								
	Incense cedar–all diameters								
Initial count	27	27	29	30	31	30	36	36	38
Number that fell	0	0	0	0	1	0	3	3	1
Fall rate for the year	0.0 pct	0.0 pct	0.0 pct	0.0 pct	3.2 pct	0.0 pct	8.3 pct	8.3 pct	2.6 pct
Avg. annual fall rate	2.5 pct								

Second, the number of years it took for half the snags to fall was calculated. We call this the half-life. Snags initially tallied in different years were assigned to separate populations. Half-lives were calculated separately for each population. Populations where more than a 50 percent decline occurred were included. The average value for included populations is reported. Source data for this calculation is provided in *table 4*. The equation is

$$\frac{\sum\left(Time\,it\,Takes\,for\,Half\,the\,Snags\,\,to\,Fall_i\right)}{n}$$

in which:

i = population based on year of death
n = number of populations

Third, the display used in Keen (1955) *(table 5, fig. 1)* of percent of snags still standing by years since death was duplicated for comparison (ponderosa pine only).

Table 4—*Half-life of snags by tree species and diameters.*

Snag counts										
	Observation year									
Population year	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**
	Jeffrey pine–all diameters									
1989	679	671	616	596	529	484	431	374	347	330
1990		55	54	51	42	39	31	21	20	18
1991			51	50	46	42	38	29	23	23
1992				35	34	34	30	29	27	22
	Jeffrey pine–13-36 cm									
1989	347	342	302	294	256	227	186	155	142	134
1990		36	35	33	26	23	19	12	11	12
1991			26	25	22	20	18	14	11	11
1992				18	17	17	15	15	13	8
	Jeffrey pine–38-74 cm									
1989	231	228	214	206	186	173	165	148	137	128
1990		16	16	15	14	14	10	8	8	5
1991			22	22	21	19	17	12	9	9
	Ponderosa pine–all diameters									
1989	471	465	449	434	413	372	341	305	273	225
1990		64	62	62	58	53	43	35	33	31
1991			79	78	74	67	55	36	28	24
1992				111	108	104	95	58	44	38
1993					68	67	62	51	43	37
	Ponderosa pine–13-36 cm									
1989	170	168	159	148	132	105	85	73	63	53
1990		25	23	23	21	17	12	8	8	7
1991			45	45	43	40	31	15	9	6
1992				78	75	73	65	36	23	20
1993					35	35	30	23	17	14

(*table 4* continued)

Population year	Observation year 1989	1990	1991	1992	1993	1994	1995	1996	1997	1998
	Snag counts									
	Ponderosa pine–38-74 cm									
1989	160	159	154	151	148	143	137	125	114	96
1990		21	21	21	19	19	16	13	11	11
1991			18	17	16	13	10	8	7	7
1992				16	16	16	15	10	9	7
	White fir–all diameters									
1989	187	186	185	179	169	161	147	130	128	87
1990		30	27	27	21	21	20	17	17	7
1991			56	56	56	54	50	47	47	26
	White fir–13-36 cm									
1989	64	64	64	61	57	51	44	38	38	21
1990		24	21	21	15	15	14	11	11	2
1991			39	39	39	38	35	34	34	21
	White fir–38-74 cm									
1989	71	71	70	68	63	61	58	54	53	40
	Western juniper–all diameters									
1989	65	65	64	62	60	59	57	52	50	50
	Lodgepole pine–all diameters									
1989	30	30	30	29	25	25	23	20	19	19
	Incense cedar–all diameters									
1989	27	27	27	27	27	26	26	24	24	24

Table 5—*Changes in snag height between 1989 and 1997.*

	All snags		Jeffrey pine		White fir	
	Count	pct	Count	pct	Count	pct
No height change	2,007	88	892	90	547	86
New height under 6 meters	165	7	55	6	75	12
New height over 6 meters	107	5	49	5	14	2
Total	2,279		996		636	
Started over 6 meters and changed	275					
New height is under 6 meters tall	151	55				

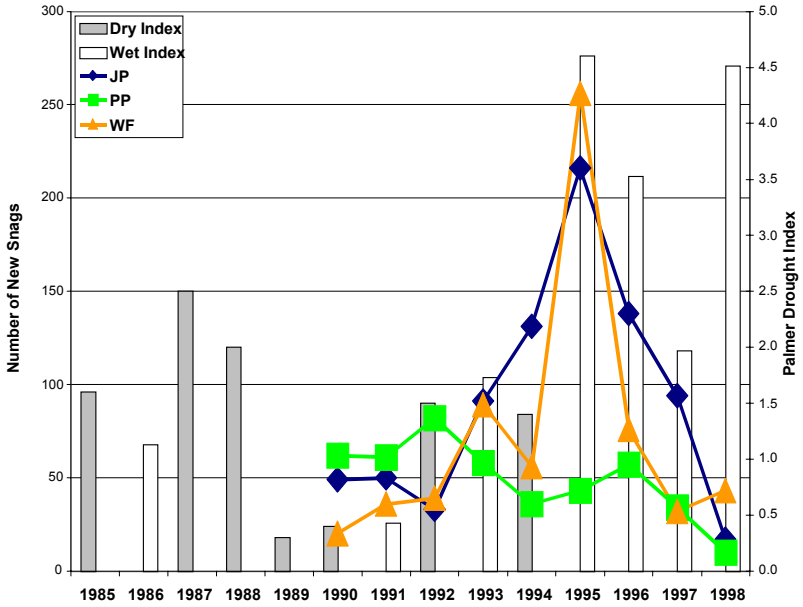

Figure 1—Numbers of new snags and the Palmer Drought Severity Index.

Results

Creation Rates

Ponderosa pine snags were created on a generally declining trend ranging from 82 to 10 total new snags on all study sites combined per year. White fir increased from 20 new snags per year to 256 in the spike year of 1995, then declined to 43 new snags in 1998. Jeffrey pine ranged from 33 new snags per year to 216 in the spike year of 1995, then declined to 17 new snags in 1998 *(table 2)*. The early part of the period was relatively dry; the latter part was relatively wet *(fig. 1)*.

Inventory

Total snag levels generally increased during the first 6 years then leveled off. Small white fir increased the most. Ponderosa pine exhibited a different pattern than Jeffrey pine and white fir *(table 3; fig. 2)*.

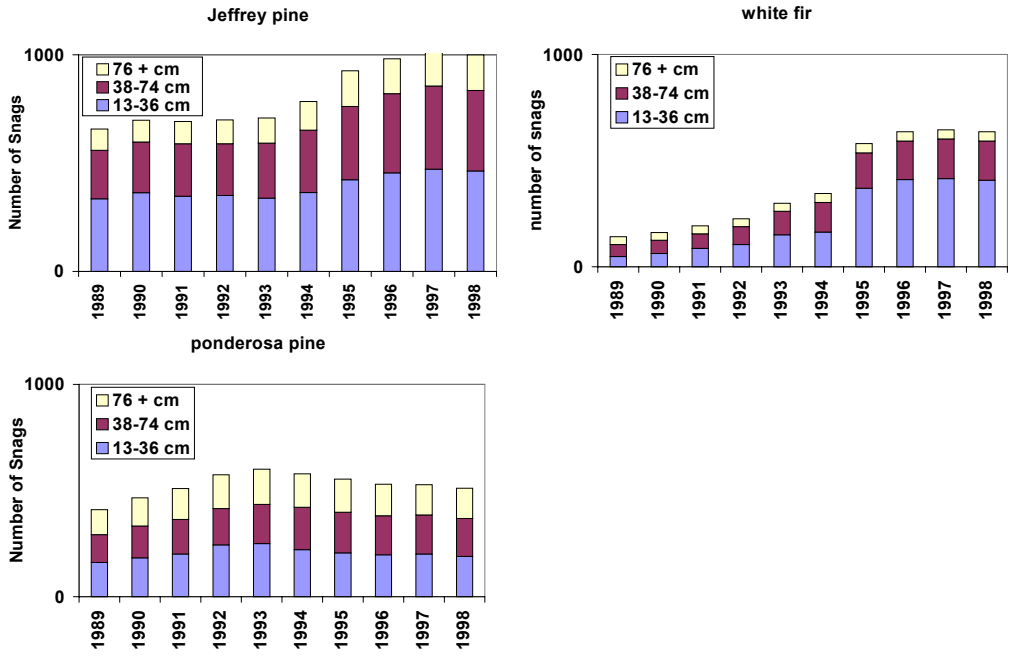

Figure 2—Numbers of snags of the three dominant tree species existing on all study sites from 1989 through 1998.

Decay Rates

Records for snags that were topped, cut, burned, or have no diameter recorded were not included in the analysis of decay rates, and only snags that were standing in 1998 were included.

For those snags standing in 1998, 88 percent retained their height during the period of observation *(table 5)*. Ninety percent of the Jeffrey pine and 86 percent of the white fir retained their height. Six percent of the Jeffrey pine and 12 percent of the white fir have new heights under 6 meters, which is considered a general suitability threshold for cavity nesting birds. This suggests that white fir tend to break off more frequently while Jeffrey pine tend to fall over. For those Jeffrey pines that did have height reduction, the average height changed from 20 meters to 7 meters. For those white firs that did have height reduction, the average height changed from 17 to 4 meters. About half (55 percent) the snags tall enough to function as cavity nesting habitat became unsuitable (under 6 meters tall).

Over the 9 years, very few snags lost bark cover. Only 4 percent of the white fir and 13 percent of the Jeffrey pine lost bark cover *(table 6)*. Among Jeffrey pine where bark cover change occurred, average bark cover changed from 89 percent to 54 percent. The corresponding change for white fir was from 99 percent to 84 percent.

Table 6—*Changes in percent bark cover.*

	All species		Jeffrey pine		White fir	
	Count	pct	Count	pct	Count	pct
No change	1,945	85	870	87	612	96
Changed	334	15	126	13	24	4
Total	2,279		996		636	

Fall Rates

Annual fall rates of snags varied by diameter and species *(table 7)*. Fall rates were greater for smaller diameter classes; for the pine species the largest diameter classes fall rates were less than half of the smallest diameter class. Both pine species had greater fall rates than the non-pines.

Snag half-life, the time required for 1/2 of the snags to fall, was less for the pine species compared to the other tree species. Western juniper snag half-lives were about twice as great as the pines *(table 8)*.

Table 7—*Average annual fall rate of snags.*

	Diameter class			
Species	All	13-36cm	38-74cm	76cm+
JP	6.8 pct	8.8 pct	5.4 pct	3.0 pct
PP	6.9 pct	10.8 pct	4.5 pct	4.2 pct
WF	3.7 pct	4.6 pct	2.7 pct	3.0 pct
WJ	2.3 pct	2.6 pct	-	-
LP	3.8 pct	-	-	-
IC	2.5 pct	-	-	-
BO	-	-	-	-
RF	-	-	-	-

Table 8—*Half-life of snags (in years).*

	Diameter Class			
Species	All	13-36 cm	38-74 cm	76 cm+
JP	6	6	7	-
PP	6	5	8	-
WF	8	7	10[1]	-
WJ	17[1]	-[2]	-	-
LP	11[1]	-	-	-
IC	-	-	-	-
BO	-	-	-	-
RF	-	-	-	-

[1] These values are outside the range of observation. They are linear trendline estimates.
[2] - Not enough observations to warrant a meaningful calculation.

Comparison with Keen (1955)

Fall rates for ponderosa pine in this study are a little more rapid than Keen reported for pure ponderosa pine observed earlier this century *(fig. 3)*. Half-life in this study is about 6 years compared to about 8 years reported by Keen (1955). Some difference should be expected due to different average diameter, 46 cm in this study compared to 61 cm reported by Keen (1955).

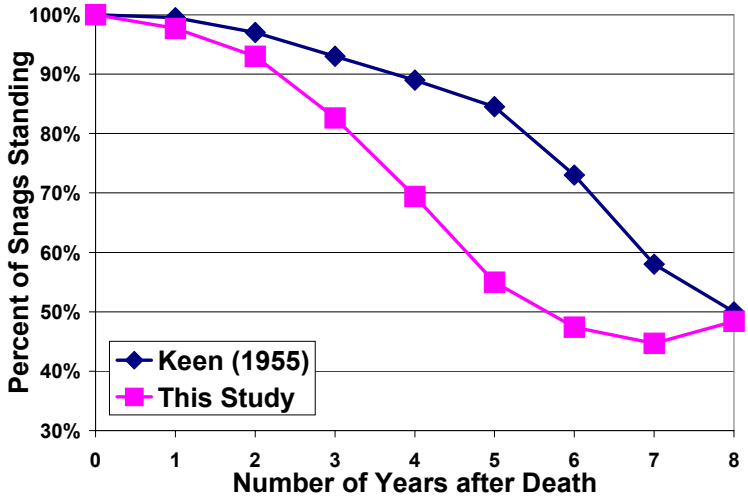

Figure 3—Losses of snags through time comparing Keen's (1955) results with those reported here.

The Influence of Fire

Site BM34/Roseburg, was prescribe-burned after snag observations in the fall of 1997. Including records for snags consumed or felled by fire, the average annual fall rate (all species and diameters combined) for the eight periods prior to the burn was 3 percent compared to the 20 percent rate that occurred after the burn *(table 9)*.

Table 9—*The influence of Rx fire on snag fall rate.*

Species	'89-'90	'90-'91	'91-'92	'92-'93	'93-'94	'94-'95	'95-'96	'96-'97	'97-'98
JP/PP/WF	0 pct	0 pct	0 pct	3 pct	2 pct	7 pct	9 pct	4 pct	20 pct

Three sites, BM34/125t, BM34/75Ti, and BM34Snag, were thinned and harvested in 1996 and Rx burned in 1997. By eliminating the harvested trees from the data, the influence of fire can be inferred. The average annual fall rate (all species and diameters combined) for the eight periods prior to the burn was 8 percent compared to the 19 percent rate that occurred after the burn *(table 10)*.

Table 10—*The influence of Rx fire on snag fall rate.*

Species	'89-'90	'90-'91	'91-'92	'92-'93	'93-'94	'94-'95	'95-'96	'96-'97	'97-'98
JP/PP	3 pct	3 pct	1 pct	4 pct	13 pct	7 pct	21 pct	15 pct	19 pct

The Influence of Wildfire and Harvest

Both wildfire and harvest have affected some of the study sites. Virtually all trees on the N Mud Lake site have been killed by wildfire; only 12 snags remain on the 5-hectare site. Several of the sites within Blacks Mountain Experimental Forest have been harvested as part of a long-term research project. The consequence of harvest on fall rate can obviously range from insignificant to highly significant.

Discussion

These results should help people predict decay rates and fall rates for snags at the landscape and larger scale through time. Variation in these rates may be high, so cautious application is warranted and incorporation of variation as an objective is suggested. Silvicultural prescriptions designed to provide specified levels of snags by species and size over specified timeframes should also be informed by this study.

Creation Rates

The variation in rate of snag creation between tree species and between size classes within a species is not readily explained. More analysis is needed to gain insight in this regard. Among other factors, the density of green trees on these study sites is not known. Density can accelerate the formation of snags, especially during drought. Host specific insects and diseases may also cause different patterns of creation.

Decay Rates

The fact that 85 percent to 96 percent of the snags standing in 1998 have had no change in height or bark cover over the period of observation is not surprising, because many snags are new during the study period and those that existed initially are relatively stable. We expect significantly more top breakage and bark loss over the next 10 years.

The relative differences in decay rates between Jeffrey pine and white fir are hard to evaluate because the number of years since death is not known for many of the snags. What appears to be faster decay in Jeffrey pine may be simply a result of older age. Many of the pine initially tagged in 1989 were killed by bark beetles in the late 1970s.

The fact that, of those trees experiencing height loss, about half end up under 6 meters tall, has significant habitat implications for some cavity dependent species. The fall rates disclosed here underestimate the snag habitat loss rates that occurred because snags of any height were included.

Fall Rates

A presumed negative exponential fall rate is not indicated in this data, probably because the observation period is too short to reflect one. Keen (1955) and Everett and others (In Press) both report a negative exponential form—one from long term observations and one from a chronosequence of wildfires.

The influence of tree species on fall rate was expected. Average annual fall rates of about 7 percent for ponderosa pine/Jeffrey pine, 4 percent for white fir/lodgepole pine, 3 percent for incense cedar, and 2 percent for western juniper seem appropriate in the absence of fire for mid-term planning at landscape and larger scales. More time is needed to verify an exponential rate for longer term planning.

The influence of tree size on fall rate was generally expected. For ponderosa pine/Jeffrey pine, average annual fall rates of about 10 percent for smaller snags, 5 percent for medium sized snags, and 4 percent for large snags were observed. The reader is cautioned that understanding the calculation method is important when interpreting these results. As used here, annual fall rate is the number of snags falling in a given year expressed as a percentage of snags that were present at the beginning of the year. Each year stands on its own. The calculation is made separately each year.

The influence of fire is significant. Prescribed burning significantly increases snag fall rates for at least 1-year after the fire occurs. Plans that include periodic prescribed burns should combine average annual fall rates with periodic increased rates during burn years.

The effect of site variables such as micro-climate, soil, slope position, disease, and disturbance history have not been adequately examined but are expected to influence both decay rate and fall rate.

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