Historic Ponderosa Pine Stand Structure of Mollisols, and Mollic Integrade Soils on the Kaibab National Forest, 10/2008

Purpose of Analysis: This analysis attempts to determine historic vegetative stand structure (grassland, open or closed forest stand) of ponderosa pine dominated Mollisols (those soils with a high accumulation of surface organic matter common in grasslands), and Mollic integrade soils (those soils with thinner organic matter accumulations in the soils surface) on the Williams and Chalender Districts of the Kaibab National Forest.

The central question posed is whether current ponderosa pine vegetation types or the (Ponderosa Pine Forest PNVT) found on Mollisol and Mollic integrade soils were dominated by open (less than 30% tree canopy cover) or closed stands (greater than 30% tree canopy cover) or were they grasslands (less than 10% tree canopy cover) historically that have been invaded by trees through disturbances or lack thereof? Open stands have non-interlocking tree crowns and have large interspaces between trees. Closed stands have small spaces between trees or have nearly interlocking crowns. Closed stands with more than about 60% canopy cover have interlocking crowns. Other Forest soils that do not classify as Mollisols or Mollic integrades exist on the Forest but were not included in this study.

Historic ponderosa pine stand structure will be determined through air photo change detection interpretation and on-site investigation by TES ecological unit (integration of soil, vegetation and climate). Historic stand structure is based on analysis and comparison of past and current canopy cover (aerial photo, field sheets), size and age class and presence of old stumps on-site. Findings on canopy covers can serve as a proxy to determine approximate basal area which is a major tool used to describe desired conditions by vegetation type. This information will be useful to determine any current deviation from historic (reference conditions) of Forest stand structure that signifies an ecological need for changes in the 2008 Forest Plan revision process and may guide identification of desired conditions. This information is intended to be used internally (by Forest Plan Revision Interdisciplinary Team members) and has not been edited, peer reviewed or submitted for publication.

Historically, periodic fire disturbance (average fire interval around 5 – 36 years, TNC. 2006) in ponderosa pine is believed to have maintained Ponderosa Pine in more open, less dense stands. Historically, frequent ground fires are believed to have caused seedling and sapling tree mortality resulting in more open stands and larger grassy interspaces compared to current conditions. Contemporary disturbances (fire suppression, grazing, and drought) have produced greater acres of closed canopy forest, altered fire regimes and ecological conditions associated with closed canopies.

In addition, the information collected and reported here could be useful in comparing, supporting and validating information presented in VDDT modeling.

Methodology: For the purpose of this analysis**,** historic conditions represent those conditions of 100-125 years or older (generally pre-1900). Canopy cover of ponderosa

pine vegetation types were interpreted from 1949 resource photographs by TES ecological unit and compared to 2006 vintage digital orthophoto quads to determine change in canopy cover over time, by size class of trees. 76 representative (based on average canopy cover appearance on photos) sites (photo stops) were compared and about 68 were visited on-site. These sites selected ponderosa pine vegetation types dominated by either Mollisol soils or Mollic integrade soils. Not all TES map units containing Mollisols or Mollic integrades were sampled and 1949 vintage photos were absent in northern portions of the Chalender District so a 1949 change detection did not occur for portions of the study. In addition, many other ponderosa pine vegetation types occur on many other non-Mollisol soil types on the Forest but are not specifically studied in this analysis.

The Williams and Chalender Ranger Districts were sampled because they make up large areas of Ponderosa Pine PNVT on the Forest and are known to currently be dominated by closed stands (generally greater than 30-50% canopy cover) and are believed to have been dominated by more open stands (less than 30% canopy cover) including grasslands. Neither the Tusayan Ranger District nor the North Kaibab Ranger District was sampled. Results and conclusions found in this analysis may not accurately reflect historic ponderosa pine stand structure in these areas. Additional investigation should occur to estimate historic stand conditions on these Ranger Districts.

All Mollisol and Mollic integrade TES map units on the Williams and Chalender Ranger Districts were sampled and field visited in this study using a "representative" map unit approach. Representative map unit polygons were selected and plotted on aerial photographs where canopy closures appeared to be in the middle range of crown closure within the TES unit over the entire landscape. However, not all actual TES map unit polygons containing Mollisols or Mollic integrade soils were sampled. However, it can be hypothesized that their current and historic stand structure closely resembles stand structure found in the representative, similar soils and sampled TES map units throughout the Ponderosa Pine PNVT on these Districts.

All TES map units on the Williams and Chalender ranger Districts were sampled in this study. However, not all actual TES map unit polygons containing Mollisols or Mollic integrade soils were sampled. However, it can be hypothesized that their current and historic stand structure closely resembles stand structure found in the representative, similar soils and sampled TES map units throughout the Ponderosa Pine PNVT.

On-site field data collection was performed to validate air-photo interpretations made and collect more accurate information to predict historic stand structure on a large sample (89%) of photo stops. On-site investigations included collection of canopy cover (ocular estimation) by three size classes, small (<11"DBH, medium (11-20" DBH), and Large (>20 " DBH). Stumps were noted and a corresponding projected historic canopy cover estimated. Tree age was determined through the use of a tree auger.

Historic canopy covers by TES unit were then determined by adding tree and projected stump canopy covers older than 100-125 years. A corresponding ponderosa pine stand

structure was then determined and classified into one of the following three classes; closed (>30% tree canopy cover (cc), Open (10 – 30% tree cc), or Grassland type (<10% tree cc).

A brief soil profile thumbnail description was made to validate soil classification. All field stops were photographed with a digital camera. Photos were labeled and inserted into a powerpoint program. The powerpoint program is located on the Coconino Forest server under the following area path:

J:\fsfiles\office\1900_planning\1920_land_resource_mgmt\so\fp-revision\ecosustain\ecosystem-diversity\kaibab\soil_pipos_study\knf\fp_revision\soil_analysis_photos.ppt

Please contact Rory Steinke (Coconino National Forest Watershed Program Manager) for further information at 928-527-3451 and to obtain a CD.

PNVT Classification and Limitations: Kaibab National Forest Potential Natural Vegetation Types (PNVTs) aggregated Terrestrial Ecosystem Survey (TES) map units (Ecological Units) into recognized PNVTs originally defined by The Nature Conservancy.

The TES Ecological Units (and soils) are derived from the Forest Ecological Unit Inventory, The Terrestrial Ecosystems Survey (TES) of the Kaibab National Forest, 1991. The TES is the result of the systematic analysis, mapping, classification and interpretation of terrestrial ecosystems also known as ecological types delineated and numbered in ecological units. It is the only seamless mapping of vegetation and soils available across the Forest that includes field visited, validated and correlated sites with a stringent Regional and National protocol stemming from decades of work. Major field work for the TES was completed during the period of 1979 through 1986. Soil names and descriptions were approved in 1989. Map units are identified by numbers ranging from 3 to 683.

It is important to realize that differences in ecosystem properties including soil and vegetation can occur within short distances. The TES was mapped at a scale of 1:24,000 across the landscape. Generally, small vegetation types smaller than about 10 to 40 acres were not mapped and are included in larger TES map units

Individual map units were based on data collected across the Forest and may or may not represent landscape existing conditions and potential plant community as depicted in the TES. Overall accuracy of mapping and information provided by the TES is considered reliable at the ecological unit or landscape level.

Disturbances: The published TES identifies the potential plant community (PPC) and is based on documented reference sites Forest and Region-wide under contemporary disturbances.

Within the Forest, the PPC, and therefore the PNVT indicates site potential and classified according to the late successional vegetation species that would be expected to occupy the site in the absence of major disturbance (Triepke, May 2007) derived from 'Southwest Forest Assessment Project' (TNC 2006), Appendix 2-B. Similar to *biophysical settings* conceptualized in the Interagency Fire Regime Condition Class Guidebook (v1.2, 2005), PNVTs combine potential vegetation and historic fire regime to form ecosystem classes useful for landscape assessment:

PNVT = PNV + Historic Fire Regime

The PNVTs are the result of historic disturbances but more recently developed under the absence of major, chronic disturbances believed to have been present and responsible for vegetative state canopy conditions under historic conditions. For Forest Plan revision analysis, it is necessary to produce information that compares and estimates historic vegetative state conditions to current condition to determine deviations that signify an ecological need for change.

Table 1 summarizes information by TES map unit for the estimated dominant, historic vegetative state. It is recognized that multiple ecological seral stages and vegetative states existed. For purposes of this analysis, the dominant, historic state is estimated based on soil capability and climate under historic disturbances.

Results:

Table 1 displays data collected by photo stop number used to estimate historic stand structure or vegetative state.

Complete field forms, photographs and data collected reside in the Kaibab National Forest Supervisors office in hardcopy, electronic and CD format (Rory Steinke, Watershed Program Manager).

Table 1. Data by Kaibab National Forest TES Ecological Unit

Key:

S = Small (< 11 " DBH), M = Medium (11-20"), L = Large (>20")

<10% Tree Canopy Cover = Grass Vegetative State or Stand Structure
10-30% Tree Canopy Cover = Open Vegetative State or Stand Structure
>30% Tree Canopy Cover = Closed Vegetative State or Stand Structure (may include near interlocking crowns)

All stops have tree age data taken from increment boring and tree ring counts.
Field data and additional on-site comments are located in analysis file in Supervisors Office

TES Map Unit	Photo Stop #	% Tree Canopy Cover (Photo-interp) by Size Class, 1949	% Tree Canopy Cover (Photo-interp) by Size Class, and Stand Structure/Veg State 2006	Inferred (through measurements) Historic (pre-1900) Stand Structure or Vegetative State	On-site Soil Classification & Comments
6	6	1 S	1 S, Grass	**<2% Grass**	Argiborolls. Few Pipos encroaching
6	20	1 SM, 1 L	2 SML, Grass	**<1% Grass**	Pachic Argiborolls
10	9	20 ML	35 SML, Closed	**15-20% Open**	Typic Argiborolls
10	12	35 SM, 8 L	55 SML, Closed	**15-20% Open**	Typic Argiborolls
10	23	10 SM, 10 L	55 SML, Closed,	**20% Open and Grass**	35% Grass inclusions. Typic Argiborolls
10	61	1/2-10 SML, 1/2-25 SM	35 SML, Closed	**2/3 Open, 1/3 Grass**	Typic Argiborolls. 50% grass and 50% Open EC.
10	65	5 SM, 5 L	20 SML, Open	**<10% Grass**	Not classified. Photo-interp.
37	38	Unknown	1 S, Grass	**1% Grass**	Typic Argiborolls
37	49	Unknown	2 SM, Grass,	**<2% Grass**	Not classified. Plowed, irrigated in past.
302	16	25 ML	55 ML, Closed	**>30% Closed**	TES 551 boundary point on CNF.
324	1	5 ML	<5, Grass	**10% Open**	Eutroboralfs/meadow inclusion in Pipos stand

TES Map Unit	Photo Stop #	% Tree Canopy Cover (Photo-interp) by Size Class, 1949	% Tree Canopy Cover (Photo-interp) by Size Class, and Stand Structure/Veg State 2006	Inferred (through measurements) Historic (pre-1900) Stand Structure or Vegetative State	On-site Soil Classification & Comments
324	11	25 ML	50 ML, Closed	**<30% Open**	TES 570 boundary point on CNF.
401	2	35 SML	55 ML, Closed	**25-30% Open**	Mollic Eutroboralfs
401	8	35 SML	60 SML, Closed	**25-35% Open-Closed**	Mollic Eutroboralfs
401	10	45 SML	55 SML, Closed	**35-45% Closed**	Mollic Eutroboralfs. 25% Open
401	11	50 SML	50 SML, Closed	**30-35% Closed**	Typic/Lithic Argiborolls
401	25	25 SM, 20 L	50 SML, Closed	**25% Open**	Mollic Eutroboralfs
401	50	Unknown	55 SML, Closed	**<10% Grass**	Not classified. No trees > 80 years old.
401	10	15 ML	45 ML, Closed	**20-25% Open**	TES 582 boundary point on CNF.
402	14	20 SM, 20 L	65 SML, Closed	**25% Open**	Typic Argiborolls
402	24	20 SM, 15 L	45 SML, Closed	**< 35% Open**	Some closed areas. Mollic Eutroboralfs
405	47	Unknown	35 SM, Closed	**10-15% Open**	Mollic Eutroboralfs
405	54	Unknown	50 SM, Closed	**10-15% Open**	Mollic Eutroboralfs
406	46	Unknown	50 SM, Closed	**10-15% Open**	Mollic Eutroboralfs
431	59	Unknown	30 SM, Open	**<30% Open**	Not classified. Photo-interp. Minor acres.
507	3	5 SL	15 SM, Open	**<10% Grass**	Typic Argiborolls. All Pipos < 80 years old
507	7	0-5 S	1 S, Grass	**<5% Grass**	Typic/Vertic Argiborolls
507	26	5 SML	5 SML, Grass	**<3% Grass**	Lithic Argiborolls/Ustolls. Pipos encroachment
507	45	Unknown	25 SM, Open	**5-10% Grass**	Typic/Vertic Argiborolls. Encroaching Pipos.
513	16	2 SM	2 SML, Grass	**1% Grass**	Typic Argiborolls
513	32	2 SML	5 SML, Grass	**<2% Grass**	Typic Argiborolls
513	39	Unknown	3 SML, Grass	**<1% Grass**	Typic Haploborolls
513	42	Unknown	5 SML, Grass	**5% Grass**	Argiborolls. Pipos encroaching along edge.
513	53	Unknown	25 SM, Open	**<5% Grass**	Typic Argiborolls

TES Map Unit	Photo Stop #	% Tree Canopy Cover (Photo-interp) by Size Class, 1949	% Tree Canopy Cover (Photo-interp) by Size Class, and Stand Structure/Veg State 2006	Inferred (through measurements) Historic (pre-1900) Stand Structure or Vegetative State	On-site Soil Classification & Comments
518	21	10 SML	10 SM, Grass/Open	**5-10% Grass**	Lithic Argiborolls
518	37	2 SM, 2L	5 SML, Grass	**<5% Grass**	Not classified
518	66	3 SML	5 SML, Grass	**<5% Grass**	Not classified. Photo-interp.
519	13	20 SM, 15 L	55 SML, Closed	**40% Closed**	Mollic Eutroboralfs
519	18	20 SM, 15 L	45 SML, Closed	**25% Open**	Not classified
519	22	30 SM, 15 L	55 SML, Closed	**25-30% Open**	Not classified
519	29	25 SM, 10 L	35 SML, Closed	**15-20% Open**	Lithic Argiborolls. Charcoal in soil.
519	33	20 SM, 15 L	55 SML, Closed	**20-25% Open**	Mollic Eutroboralfs
519	36	20 SM, 15 L	50 SML, Closed	**<30% Open**	Mollic and Lithic Eutroboralfs. Heavy logging
519	44	Unknown	45 SML, Closed	**20% Open**	Lithic Eutroboralfs
519	64	15 SM, 15 L	35 SML, Closed	**<30% Open**	Photo-interp. 35% grass inclusions.
525	15	35 SM, 15 L	55 SML, Closed	**30-35% Closed**	Typic Argiborolls
525	63	25 SM, 20 L	50 SML, Closed	**30-35% Closed**	Mollic Eutroboralfs
537	4	30 SML	60 ML, Closed	**25-35% Open-Closed**	Typic Argiborolls
537	17	15 SM, 20 L	45 SML, Closed	**20-25% Open**	Not classified
537	19	20 SM, 20 L	50 SML, Closed	**25% Open**	Not classified. Many have grass inclusions.
537	30	25 SM, 15 L	55 SML, Closed	**25% Open**	Typic/Lithic Argiborolls
537	34	25 SM, 20 L	60 SML, Closed	**<30% Open and Grass**	20% grass inclusions. Typic Argiborolls
537	35	20 SM, 15 L	55 SML, Closed	**<30% Open and Grass**	40% grass inclusions. Typic Argiborolls
537	40	Unknown	55 SML, Closed	**25% Open**	Mollic Eutroboralfs
537	41	Unknown	55 SML, Closed	**25-30% Open**	Typic Argiborolls
537	43	Unknown	55 SML, Closed	**20% Open**	Typic Argiborolls
537	51	Unknown	55 SML, Closed	**20% Open**	Typic Argiborolls. Recent wildfire.
537	52	Unknown	60 SML, Closed,	**25% Open**	Typic Argiborolls
537	62	15 SM, 15 L	45 SML, Closed	**<30% Open**	Not classified. Photo-interp.

TES Map Unit	Photo Stop #	% Tree Canopy Cover (Photo-interp) by Size Class, 1949	% Tree Canopy Cover (Photo-interp) by Size Class, and Stand Structure/Veg State 2006	Inferred (through measurements) Historic (pre-1900) Stand Structure or Vegetative State	On-site Soil Classification & Comments
537	67	55 SML	55 SML, Closed	**30-35% Closed**	Mollic Eutroboralfs/borolls. 10% grass inclusions
537	1	20 ML	55 ML, Closed	**<20% Open**	TES 582 boundary point on CNF.
537	20	20 ML	50 ML, Closed	**<30% Open**	TES 582 boundary point on CNF.
537	21	3 ML	10 ML, Grass/Open	**<5% Grass**	TES 582 bdy. point on CNF. Meadow inclusion.
537	22	20 ML	45 ML, Closed	**<25% Open**	TES 582 boundary point on CNF.
537	8	20 ML	50 ML, Closed	**25-30% Open**	TES 582 boundary point on CNF.
537	17	15 ML	50 ML, Closed	**<25% Open**	TES 582 boundary point on CNF.
539	60	20 SM, 15 L	35 SML, Closed	**<30% Open**	Not classified. Photo-interp. Minor acres.
540	55	30 SM, 25 L	55 SML, Closed	**>30% Closed**	Not classified. Photo-interp.
563	5	5-10 S	45 SM, Closed	**15-20% Open**	Typic Argiborolls
563	28	15 M, 15 L	40 SML, Closed	**15% Open**	Typic/Lithic Argiborolls
563	48	Unknown	60 SML, Closed	**10-15% Open**	Typic Argiborolls
564	27	10 SM, 5 L	60 SML, Closed	**20% Open and Grass**	10-20% grass inclusions. Not classified
565	31	25 SM, 15 L	45 SML, Closed	**10-15% Open**	Lithic Argiborolls. Many dead Pipos/bugs/drought
630	56	<5 SM	3 SM, Grass	**<2% Grass**	Argiborolls
648	57	Unknown	40 SML, Closed	**<30% Open**	Not classified. Photo-interp. Minor acres.
649	58	10 SM, 5 L	20 SM, Open	**<10% Grass**	Not classified. Photo-interp. Only 2 polygons.

Table 2 displays TES soil classification, % Mollisols and Mollic Integrades, TES PPC, Forest Plan PNVT, Climate Class, and summarizes Inferred Dominant Historic stand structure or vegetative state and type by TES unit. It is recognized that historic stand structure or vegetative state was variable due to different levels of disturbance but the overall dominant historic state is inferred through methods used in this analysis.

Key:

- <10% Tree Canopy Cover = Grass Vegetative State or Stand Structure
- 10-30% Tree Canopy Cover = Open Vegetative State or Stand Structure
- >30% Tree Canopy Cover = Closed Vegetative State or Stand Structure (may include near interlocking crowns)

Table 2 Mollisols and Mollic Integrade Soils on the Williams & Chalender Districts

TES Map Unit	TES Soil Classification	% Mollisols / or Mollic Integrade	TES PPC & Revised Forest Plan PNVT	Climate Class	Inferred **Dominant** Historic Stand Structure/Vegetative State and Historic PNVT Type
6	Pachic Argiborolls, deep, fine	100%	Bluegrass/AZ fescue. Montane/Subalpine Grassland	LSC, 5	Grass. Montane/Subalpine Grassland
10	Typic Argiborolls, deep, fine	100%	Ponderosa Pine/Gambel Oak. Ponderosa Pine Forest	LSC, 5,0	Open stand and up to 33% grass inclusions. Ponderosa Pine Forest and Montane Subalpine Grasslands
37	Aquic Haploborolls, deep, loam-skeletal	100%	Bluegrass/sedge/AZ fescue. Montane/Subalpine Grassland	LSC, 5	Grass. Montane/Subalpine Grassland
401	Mollic Eutroboralfs, deep, fine, gr-cl	10/80%	Ponderosa Pine/Gambel Oak. Ponderosa Pine Forest	LSC, 5,0	Majority Open stand. Minority Closed and very few Grass states. Ponderosa Pine Forest
402	Mollic Eutroboralfs,	90%	Ponderosa Pine/Gambel Oak.	LSC, 5,0	Majority Open stand. Minority Closed.

TES Map Unit	TES Soil Classification	% Mollisols / or Mollic Integrade	TES PPC & Revised Forest Plan PNVT	Climate Class	Inferred **Dominant** Historic Stand Structure/Vegetative State and Historic PNVT Type
	deep, fine, cinv-l		Ponderosa Pine Forest		Ponderosa Pine Forest
405	Mollic Eutroboralfs, fine, grv-cl	10/90%	Ponderosa Pine/Pinyon/Gambel Oak. Ponderosa Pine Forest	HSC, 5, -1	Open stand. Ponderosa Pine Forest
406	Mollic Eutroboralfs, mod. deep, fine, cinv-l	100%	Ponderosa Pine/Pinyon/Gambel Oak. Ponderosa Pine Forest	HSC, 5, -1	Open stand. Ponderosa Pine Forest
431	Mollic and Lithic Eutroboralfs, mod. deep and shallow	10/90	Ponderosa Pine/Pinyon/Gambel Oak. Ponderosa Pine Forest	HSC, 5, -1	Open stand. Ponderosa Pine Forest
507	Vertic Arigiborolls, fine, grv-cl	90%	Rabbitbrush/fescue/blue grama. Ponderosa Pine **Forest (should be changed to Great Basin Grasslands)**	HSC, 5, -1	Grass. Great Basin Grassland
513	Typic and Pachic Argiborolls, mod. deep and deep, clayey-skeletal and fine, cb-cl and loam	100%	Fescue/muhly. Montane/Subalpine Grassland	LSC, 5, 0	Grass. Montane/Subalpine Grassland
518	Lithic and Typic Argiborolls, shallow, mod. deep, clayey-skeletal and fine, cbv-cl	100%	Fescue/muhly. Montane/Subalpine Grassland	LSC, 5, 0	Grass. Montane/Subalpine Grassland

TES Map Unit	TES Soil Classification	% Mollisols / or Mollic Integrade	TES PPC & Revised Forest Plan PNVT	Climate Class	Inferred **Dominant** Historic Stand Structure/Vegetative State and Historic PNVT Type
519	Lithic Eutroboralfs and Lithic Argiborolls, clayey-skeletal and fine, cbv-cl	50/50%	Ponderosa Pine/Gambel Oak. Ponderosa Pine Forest	LSC, 5, 0	Majority Open. Minority Closed. Ponderosa Pine Forest
525	Typic Argiborolls, fine and clayey-skeletal, mod. deep, cbv-l and Rock Outcrop	65%	Ponderosa Pine/Gambel Oak Ponderosa Pine Forest	LSC, 5,0	Closed stand. Ponderosa Pine Forest
537	Mollic Eutroboralfs, mod. deep, fine, cbv-cl and Typic Argiborolls, clayey-skeletal, cb-cl	45/55%	Ponderosa Pine/Gambel Oak Ponderosa Pine Forest	LSC, 5, 0	Majority Open, minority closed. Grass inclusions common. Ponderosa Pine Forest and Great Basin Grassland inclusions
539	Typic Argiborolls, mod. deep and Rock Outcrop	60/40%	Ponderosa Pine/Gambel Oak Ponderosa Pine Forest	LSC, 5	Open stand. Ponderosa Pine Forest
540	Typic Eutrochrepts and Udic Haploborolls, and Rock Outcrop	45/0%	Douglas Fir/Ponderosa Pine/Juniper/Turbinella Oak Mixed Conifer Forest	LSM, 6, -1	Closed stand Mixed Conifer Forest
563	Mollic Eutroboralfs, mod. deep, clayey-skeletal, cbv-cl and Typic Argiborolls, fine, cb-cl	45/55%	Ponderosa Pine/Pinyon/Gambel Oak Ponderosa Pine Forest	HSC, 5, -1	Open stand Ponderosa Pine Forest
564	Typic Argiborolls, mod. deep, clayey-skeletal and fine, cb	90/10%	Ponderosa Pine/Pinyon/Gambel Oak	HSC, 5, -1	Open stand and grass inclusions. Ponderosa Pine and Great Basin

TES Map Unit	TES Soil Classification	% Mollisols / or Mollic Integrade	TES PPC & Revised Forest Plan PNVT	Climate Class	Inferred **Dominant** Historic Stand Structure/Vegetative State and Historic PNVT Type
	and cbv-l		Ponderosa Pine Forest		Grassland inclusions
565	Lithic Argiborolls, clayey-skeletal and fine, cbv-l and cbv-cl	90/10%	Ponderosa Pine/Pinyon/Gambel Oak Ponderosa Pine Forest	HSC, 5, -1	Open stand Ponderosa Pine Forest
630	Lithic and Mollic Eutroboralfs, shallow and mod. deep, clayey-skeletal, gr and grv-l	0/100%	Arizona fescue/muhly Montane/Subalpine Grassland	LSC, 5, 0	Grass Montane/Subalpine Grassland
648	Typic and Lithic Argiborolls, mod. deep and shallow, cbv l	70/10%	Ponderosa Pine/Pinyon/Gambel Oak Ponderosa Pine Forest	HSC, 5, -1	Open stand Ponderosa Pine Forest
649	Vertic Argiborolls, mod. deep, fine, cbv-cl	100%	Ponderosa Pine/Pinyon/Gambel Oak Ponderosa Pine Forest	HSC, 5, -1	Grass (only 2 polygons) Great Basin Grassland

On-site soil profile descriptions revealed the vast majority of selected sites classified the same or very similar to TES map unit soil classification. Field notes and photographs are included in an accompanying power point document each stop.

Discussion:

Soils: Mollisol presence indicates that historically, the soil was probably dominated by a competitive, herbaceous understory layer or grassland that broke down and formed a thick (7 – 10 inches or more), organic layer over time, especially on deep soils (> 40 inches to bedrock).

Mollisols on deep or moderately deep soils have a higher capability (greater water holding capacity) to support more biomass including herbaceous understories than on rocky or shallow Mollic integrade soils. Historically, Mollisols probably included large interspaces dominated by grassy, herbaceous understories capable of outcompeting trees for soil moisture and nutrients and carrying ground fires that resulted in seedling and sapling mortality, open canopies, grassy interspaces and fewer trees.

Summary of Field Findings

Soil Classification: TES published soil classification by map unit appears to be very accurate at the level and scale of mapping (1:24,000). Field soil classification indicated the same or very similar axons on the vast majority of stops. Small grass inclusions (generally less than about 60 acres) were not individually delineated and at the mapping scale of 1:24,000 are designed as inclusions within each mapping unit. Field data and analysis of Table 2 indicate there are 24 TES map units with high amounts of Mollisol or Mollic integrade soils on the Chalender and Williams Ranger Districts.

PNVTs: Approximately 68 sites were field visited. 55 sites were identified in Forest Pan revision as Ponderosa Pine Forest PNVT, 12 others mapped as Montane/Subalpine Grassland PNVT and 1 mapped as Mixed Conifer Forest PNVT. Forest Plan revision PNVTs were derived from aggregations of TES PPC's. TES unit 507 was identified as Ponderosa Pine Forest in Forest Plan revision but the TES PPC supports a Great Basin Grassland.

Current Ponderosa Pine Stand Structure: Analysis of Table 1 from 55 field stops indicates that about **84%** of the Ponderosa Pine PNVT currently has "**Closed**" stand structure. On-site, field canopy cover validations were virtually identical to photo-interpretations. The remaining Ponderosa Pine PNVTs indicate. 9% are **Open** and 7% are **Closed** states (table 3)**.**

The other stops visited have one Mixed Conifer Forest with **Closed** stand structure and several Montane Subalpine Grassland photo dominated by the **Grass** vegetative state.

Table 3, Summary of Data Findings:

Current Ponderosa Pine Stand Structure **(from Photo Interpretation and Field Validation and analysis of Table 1 and 2).**	**Inferred Historic Ponderosa Pine Stand Structure Range** **(from analysis of Table 1 and field findings)**
84% "Closed" (46 out of 55)	16% "Closed" (9 out of 55)
9% "Open" (5 out of 55)	69% "Open"(38out of 55)
7% "Grassland"(4 out of 55)	15% "Grasslands**" (** 8out of 55)

Historic Ponderosa Pine Stand Structure: This stage of the analysis estimated that most sites (about 38 out of 55 stops or 69% in Ponderosa Pine PNVTs were inferred to have open stands historically. About 9 out of 55 stops or 16% were inferred to be closed stands and 8 out of 55 or 8% were grassland states historically.

TES PPC and Historic PNVT Comparisons: Field data and analysis of Table 2 indicate all 24 Mollisol or Mollic integrade TES map units PPC's equate to the historic PNVT determined in this study except for minor differences in 5 TES map units.

TES unit 649 is currently identified with a PPC of Ponderosa Pine/Pinyon/Gambel Oak but data indicates this has an historic PNVT of a Great Basin Grassland. There are only 2 polygons located near Sycamore canyon on these 2 districts.

TES units 10, 537 and 564 have TES PPC's identified as Ponderosa Pine/Gambel Oak or Ponderosa Pine/Pinyon/Gambel/Oak and findings indicate the majority of acres have an historic PNVT of Ponderosa Pine but also may have appreciable Grassland PNVT inclusions within many polygons. These inclusions make up to about 50% in TES unit 10 and up to 40% in TES units 537 and 564. These Grassland inclusions are generally relatively small (less than about 40 acres in patch size) and within TES map unit delineation limitations and therefore were identified as inclusions in map unit design. Most other TES units appear to have smaller grass inclusions.

Map Unit Needing Correction in Forest Plan Analysis:
Map unit 507 is currently included as a Ponderosa Pine Forest PNVT in the revised Forest Plan map. This unit was and should be recognized as a Great Basin Grassland in both the TES and the findings of this study.

Conclusions:

The central question posed was whether current ponderosa pine vegetation types found on Mollisol and Mollic integrade soils were dominated by open (less than 30% tree canopy cover and non-interlocking) or closed stands (greater than 30% tree canopy cover with near interlocking canopies) or were they grasslands (less than 10% tree canopy cover) historically that have been invaded by trees through disturbances or lack thereof?

The answer is yes, Ponderosa Pine vegetation types were and are found on Mollisol and Mollic integrade soils historically but tree density has increased dramatically over time. Understanding the historic vegetative stand conditions determined in this informal study by TES unit should help guide the identification of plan component desired conditions be it full restoration (including role of fire) or no restoration because it is based on the inter-relationship between climate, vegetation and soil capability.

This analysis concludes that the Ponderosa Pine PNVT was dominated (possibly around 69%, see Table 3) by an open stand structure (10 – 30% canopy cover) on Mollisols and Mollic integrade soils and was not historically dominated by "Grass" vegetative states or Montane Meadows/Subalpine Grassland or Great Basin Grasslands PNVTs.. However, many open stands supported "Grass" vegetative state inclusions variable in size (maybe from 1-60 acres) in several TES map unit but were most noteworthy in the following map units; 10, 519, and 537. Current and historic Montane Meadow/Subalpine Grassland PNVTs are dominated by Mollisols where fire played a major role.

In addition, the Ponderosa Pine PNVT occurs on other non-Mollisol soils throughout the Kaibab National Forest. Therefore, historically, Ponderosa Pine vegetation types were found on Mollisol soils and the great majority of sites were not grassland sites invaded by ponderosa pine. However, it is clear that over time, the majority of the Ponderosa Pine PNVT located in the Williams and Chalender Districts has increased in density and canopy cover with the lack of fire disturbance in the ecosystem.

All sampled plots determined to be closed historically had less than about 45% crown closure (30-45%). This amount of closure could be described as "near interlocking" crown closure. No "closed" historical stand structures fell into an "interlocking" crown closure category common in very dense forests in the TES units analyzed.

Based on the findings of this study, closed stands with more than about 60% canopy cover with interlocking crowns were not common in these soils historically. Other Forest soils that do not classify as Mollisols or Mollic integrades exist on the Forest but were not included in this study. Personal observations made indicate that the majority of these soils and stands are currently closed and historically were less dense and had less dense canopy closures. It is not known what percentage of these soils and stands were open or closed.

Most sites visited in Ponderosa Pine PNVT's appear to have been historically dominated by open forest stands (20-30% tree canopy cover range). Historically, these soils probably supported clumps of trees and grassy interspaces. It is speculated that Mollisol and Mollic integrade soils supported more herbaceous biomass in interspaces than soils with thinner organic surface horizons. Personal observations made indicate non-Mollisol or Mollic integrade soil types are dominated by Closed stands and appear to have been more Open historically. However, it is not known what percentage of these soils and stands were open or closed.

Results of this analysis cannot conclude that thinner organic soils without a Mollic epipedon or Mollic integrade (generally perceived to be forest soils) have smaller, less herbaceous interspaces and greater tree canopy covers than Mollisol and Mollic integrade soils because it was not analyzed. Another similar study of forest soils with thinner organic surfaces (with ochric epipedons) would have to occur to determine historic stand structure.

Historic canopy covers were probably variable but dominated by "Open" stand structure and non-interlocking canopies. Natural fire disturbance probably maintained these stands in "Open" states. It should be hypothesized that the entire Forest was not historically "Open" because multiple seral stages probably existed forest-wide following fire disturbance or lack thereof creating areas of "Open", "Closed" and early seral "Grassland" states.

Comparisons to Coconino National Forest Midscale data: For comparison purposes, the Midscale Ponderosa Pine PNVT vegetation modeling shows 84% of PNVT is currently in "Closed" states, 12% is "Open" and 4% in "Grass" state. This analysis shows similar numbers as follows, "current "Closed" state is about 84%, 9% "Open", and 7% "Grass" states. Comparisons to Kaibab midscale data can and should be made.

Midscale historic modeling (Coconino National Forest Ponderosa Pine Risk Assessment, 2007) shows reference conditions to be solely dominated (100%) by "Open" stand states while this analysis infers about 69% "Open" with the remainder including "Closed" and "Grassland" states. It is doubtful that 100% of the Forest was dominated by "Open" vegetative states as VDDT modeling suggests. A better understanding and analysis of VDDT modeling figures is needed to accurately compare results with this analysis.

Many mapped Ponderosa Pine PNVTs (especially in TES units 10, 519, and 537 have large inclusions of grass vegetative states (Montane/Subalpine PNVT) within Ponderosa Pine PNVT where the scale of TES mapping limited delineations finer than about 40 acres in size. These polygons would better fit into grassland PNVT's if finer detailed mapping is desirable.

Closed stands with more than about 60% canopy cover have interlocking crowns but based on the findings of this study, were not common in these soils historically.

Grassland vegetation types and PNVTs: (Great Basin and Montane/Subalpine Grassland PNVTs) occur on Mollisol soils also but have been maintained historically and currently by recurring fire disturbance. Montane/Subalpine grasslands are identified by TES units 6, 37, 513, 518 and 630. TES unit 507 should be identified as Great Basin Grassland

These soils are Mollisols (except TES 630, Mollic integrade) and currently classified as Grasslands where tree canopy cover is much less than 10%. Larger meadow patches have static boundaries and few pine trees invading the site except some encroachment along the meadow edge.

Mixed Conifer PNVT's: were observed to have "Closed" stand structure with interlocking canopy covers well over 30 – 50%.

Pinyon-Juniper Woodland PNVTs: Personal observations made on both the Kaibab and Coconino National Forests indicate current stand structures are much denser that what may have existed historically. Follow-up analysis of Pinyon-Juniper Woodland PNVTs historic vegetative conditions is recommended.

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