Evaluation and Utilization of the Continuous Forest Inventory System at Swanton Pacific Ranch

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ABSTRACT

Five Continuous Forest Inventories (CFI) and one Senior Project Inventory (Piper et al. 1989) at Swanton Pacific Ranch in Davenport, CA were compiled and standardized to be formatted for input into Forest and Stand Evaluation Environment (FORSEE) growth and yield modeling software. Data from field books and Excel spreadsheets located on the Cal Poly Natural Resources Management Department hard drive was transcribed into a Microsoft Excel database. Data sources and authenticity were verified by cross-referencing plot data from multiple sources; associated senior project reports, and location on the Swanton grid system. An additional summary spreadsheet was made to help users select and establish confidence in the data. This project standardizes the Swanton timber inventory system creating a powerful CFI database to support future forest management decisions at Swanton Pacific Ranch.
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INTRODUCTION

Ever since the NRM department became involved with Swanton Pacific Ranch, there has been a need to monitor the condition of the timber resources in a consistent and replicate manner in accordance with sustainable management. In 1989, a senior project was undertaken by undergraduates Kevin Piper and John Anderson (Piper et al. 1989) to quantify the timber resources of the Little Creek watershed and other forested regions of the ranch. This supported initial forest management activities (i.e., the Pioneer and Tranquility Timber Harvest Plans, and the 1991 Swanton Forest Management Plan (Big Creek Lumber Company 1991)). In 1997, another senior project was undertaken by Larry Bonner (Bonner 1997) to build upon the initial inventory and establish an official CFI system according to NRM departmental standards (Pillsbury 2009). All subsequent inventories have been based on Bonner’s system with some new plots established in later years, but the data has not yet been converted into a standardized format. It is within the interest of the NRM department, Swanton Pacific Ranch, and the California Growth and Yield Modeling Cooperative (CAGYM) to complete this database project.

Additionally, there is now enough significant historical data to compare and model changes within the school forest through time. Dr. Piirto, the NRM Department Head, has expressed an interest in using this data to critically analyze and critique the historical management by modeling the growth, change, and regeneration of the forest using FORSEE.
Scope

One of the challenges we faced was defining the scope of our senior project. This morphed consistently throughout the whole process as we dug deeper into the datasets. Originally we were planning to re-measure select plots in Little Creek from 3 previous senior projects (Bonner 1997, Cross 1993, and Piper 1989) and evaluate change within the stand since Cal Poly’s acquisition of Swanton Pacific Ranch. We opted to use CFI data instead since it had been established on a permanent grid (Reimer 1993, and Bonner 1997) and was easier to replicate. Using CFI data also eliminated our need to re-measure plots since a post-fire mortality assessment had been completed in 2010 (Auten 2010). The CFI system is much more comprehensive and statistically able to account for disturbances (harvest entries and wildfire). The project was then defined as it is now: the standardization and compilation of these CFI datasets and Piper’s 1989 inventory onto the same spreadsheet designed for FORSEE modeling.
BACKGROUND INFORMATION

Swanton Pacific Ranch

Swanton Pacific Ranch is located just north of Davenport, CA on the Scotts Creek watershed. It is a working ranch that serves as an educational facility for Cal Poly students. The ranch operations are three pronged; natural grass-fed beef, certified organic crops and Forest Stewardship Council (FSC) certified selective forestry. The Ranch is located on 3200 acres; of which 1600 are forested. Redwood forests in the area were historically cut between 1901 and 1929 to rebuild San Francisco after the 1908 earthquake. The area has had additional logging entries as late as 1970 (Big Creek Lumber Company 1991). Cal Poly’s history with the ranch began in 1986 when the owner, entrepreneur, and Cal Poly graduate Al Smith leased it to the school for use as an outdoor working laboratory. In 1989, forestry student Kevin Piper conducted the first official timber inventory in the Little Creek area (Piper et al. 1989). This inventory was used to write first forest management plan in conjunction with the Big Creek Lumber Company (Big Creek Lumber Company 1991). Big Creek Lumber has a long history of working together with Cal Poly to achieve forest management goals at and around the ranch. This document outlined the objectives for timber management on Swanton Pacific Ranch. It designated Little Creek as the managed area of interest and identified uneven aged silviculture as the method. Group selection and single tree selection are the two harvesting methods that are currently used on the ranch. This was the basis of several timber harvests including Tranquility and Pioneer timber harvest plans (THP). In 1997,
forestry student Larry Bonner established an official CFI system and recalibrated the local volume equation which was found to not adequately account for stand variability (Bonner 1997).

In 1999 Steve Auten expanded the CFI system (Auten 1999) by establishing plots on the Scotts Creek forested region of the ranch. The system was expanded again in 2003 to include the Satellite units surrounding the Little Creek area. These data sets were important because they would eventually be used to create a Non-Industrial Timber Management Plan (NTMP). NTMPs are great tools for private landowners in California as they provide the means and planning for continual management and harvesting activities without having to prepare a THP document for each entry. It lasts in perpetuity and is a great way to incorporate present and future management goals. In 2008 the first harvest took place under the new NTMP in Little Creek. The 2008 CFI was conducted immediately after the harvest. In August of 2009, the Lockheed fire burned through most of the Little Creek drainage. This was an extremely significant disturbance because of the high intensity of the fire. A mortality assessment was conducted under forester Steve Auten after the fire to predict the tree mortality within the affected stands (Auten 2010). This data was used to draft the marking protocols for the salvage harvest that took place in the spring of 2010. The fire had a drastic effect on the efforts to develop an uneven age forest at Swanton Pacific Ranch. A key component of this project is developing a data set that will help define the direction future management will go.
Coordinate System

The coordinate system at Swanton Pacific Ranch has undergone many changes since it was first officially documented and used for plot location in Piper’s 1989 inventory. The Northing baseline for all versions of the coordinate system is tied in to USGS benchmark 1238N, which is located on the Little Creek Bridge at the intersection of Little Creek and Swanton Road. Along this baseline, grid and plot points are located at 500 ft. intervals which mark the intersection of Easting coordinate lines. Later on, permanent points were surveyed and established by a third party engineering firm as part of the Little Creek Road survey (J. L. Reimer, 2010, pers. comm.). These are completely independent to the grid and CFI system, but are often used as tie points for surveys or plot location.

Locating plots on a grid system with 500 ft. intervals had been formulated by NRM faculty at Swanton in conjunction with early growth and yield classes. John Todd completed a senior project which mapped the vegetation types of little creek at these 500 ft. intervals (Todd 1988). He created a map of plot locations where he did each of his vegetation surveys but did not mark his plot locations in the field because his plots were not permanent. However, they do appear to line up reasonably well with the NTMP vegetation types according to NRM faculty and ranch staff (D. Piirto, 2010, pers. comm.)

Originally, the benchmark was established as point (0E, 0N) on the grid system. Piper et. al. and department faculty recognized the potential issue of having negative coordinates in quadrants II, III, and IV, and adjusted the coordinate system appropriately. The benchmark location was converted to point (18E, 19N) and all of Todd’s theoretical
plot locations were converted to reflect this. The 1989 inventory plot centers were located from the easting baseline and Todd’s 1988 vegetation map using a staff compass, cloth tape, and clinometers.

In 1993, Jeff Reimer and Tim Maskrey installed stand designation boundaries for their senior project. They also adjusted the coordinate system to make it work better with the 500 ft. intervals by designating the benchmark as (10000E, 10000N) (Reimer and Maskrey 1993). This is the current designation upon which all subsequent inventories have identified their plot locations starting with 1997 (Bonner 1997).

**FIGURE 1. Development of the Coordinate System at Swanton Pacific Ranch**

![Diagram of coordinate system development]

Growth and Yield Classes  Piper et. al 1989  Maskrey and Reimer 1993
FORSEE Growth and Modeling Software

FORSEE is a Windows based computer program based on CRYPTOS (Cooperative Redwood Yield Projects Timber Output Simulator) and CACTOS (California Conifer Timber Output Simulator), two DOS-based forest growth and yield simulators. What makes FORSEE unique is that it is not only designed for growth and yield modeling, it is an engine that is capable of integrating other similar types of forest computer modeling: fuels, vegetation, regeneration, etc. (F. G. Schurr, 2010, pers. comm.).

Currently FORSEE is in its beta version as it is continuously being updated with more accurate localized tree data, more species, and reliable carbon content equations, but it is very powerful and capable of custom modeling with specific user inputs and outputs. It is within the interest of Dr. Piirto to utilize this program to generate stand characteristics for each of the datasets at their respective dates for comparison.

Description of Datasets

Piper et al., Little Creek, 1989

This was the first inventory that was completed at Swanton Pacific Ranch. It was conducted by Kevin Piper, Craig Kelly, and John Anderson as their senior project. The original inventory was projected to be 100 plots, 52 of which were actually measured at this time. The measured plots are primarily located along the Little Creek watershed (Piper et al. 1989). Several other plots were found in the appendix for this inventory, but
some of them appear to be done independent of Piper’s work, either as separate inventories or through previous NRM Growth and Yield Classes.

**Bonner, Little Creek, 1997**

This inventory was the first set of official CFI data and was Larry Bonner’s senior project. It measured a total of 35 plots in the Little Creek drainage. There were 36 plots locations identified, but one plot was not measured because it was all tanoak (*Lithocarpus densiflorus*) (Bonner 1997).

**Auten, Scotts Creek 1999**

This inventory was the first and only set of CFI plots done in the Scotts Creek tract of Swanton. It was conducted by Steve Auten in 1999 and consists of 46 new plots on the grid system. The same tree measurement protocols were used per 1997, but a new protocol was developed for regeneration (Auten, 2000).

**Anderson, Satellite Units, 2003**

This CFI dataset was collected by Paul Anderson. Most data was collected from plots in the Archibald Creek area and in the satellite units. There were also some new CFI plots added on grid coordinates that did not previously have CFI plots (Anderson 2003). One problem with this data set is that the growth from tree increment bore samples was measured in centimeters instead of inches which has been the standard for Swanton CFI protocols (S. R. Auten, 2010, pers. comm.).
NTMP (Non-industrial Timber Management Plan), Little Creek, 2008

This CFI dataset was completed after the summer harvest in the North fork of Little Creek. The main purpose was to measure which trees were removed in the harvest and to establish a relative baseline from which to measure growth in the residual stand. 2008 was the first harvest conducted under the new NTMP (S. R. Auten, 2010, pers. comm.). These are the same plots originally conducted by Bonner in 1997 and the most current.

Post-Fire Mortality Assessment, 2010

This entry was not an official inventory, but a qualitative modifier developed to predict mortality caused by the 2009 Lockheed Fire on CFI plots. It used crown sprouting, basal sprouting, and crown scorch as indicators of tree mortality and was the basis for marking protocols of the 2010 salvage harvest. The physical tree attributes (height, DBH, etc.) from the 2008 inventory are assumed to have remained constant (where 2008 plot data does not exist in the satellite units, 2003 physical attributes are assumed). The predictor variables were selected by reviewing previous scientific literature on assessing tree mortality. (Auten 2010)
PURPOSE AND OBJECTIVES

The purpose of this project is to prepare a standardized database of all Swanton’s inventory data for Dr. Piirto, Swanton Pacific Ranch, NRM faculty, staff, and future Cal Poly students. This database is designed specifically for FORSEE to be analyzed in any number of ways.

The objectives of this project are:

1. To compile and standardize 6 historical timber resource inventory datasets from Swanton Pacific Ranch into a standard format for future data management purposes.

2. To prepare the datasets for input into FORSEE growth and yield modeling software

3. To assist Dr. Piirto in selecting a sample population from the database for a critical review and observational study of the effects of uneven management in the Little Creek drainage.
PROCEDURES

Spreadsheets

We developed and compiled 3 separate spreadsheets: a master FORSEE spreadsheet to be used for vegetation modeling, an independent comprehensive 1989 inventory spreadsheet of Piper’s senior project field data, and a verification spreadsheet to aid the user in selecting a sample population and establishing confidence.

FORSEE Spreadsheet1

The FORSEE spreadsheet was designed by Christopher Hipkin of Statewide Forestry Services as a “flat file” or barebones spreadsheet with all the raw data organized in an easily accessible format to be entered into Access or other database software. Many of the given datasets were gathered using different rubrics, so every field in the master spreadsheet has an associated legend within a separate legend tab. This spreadsheet contains all of the data sets (1989, 1999, 2003, 2008, and 2010) in the same format and will be the basis of all modeling. It is the most current and standardized source from which all plot data should be used in the future.

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1 Located on Project Disc. Senior Project Folder\Spreadsheets\SwtnAllPlotData19oct2010
89 Swanton Data Spreadsheet²

In theory, this data is on the same coordinate system, but it was done before the official CFI system was established and stands independent. It also was its own senior project so we elected to create another spreadsheet for the department to have should anything be done further with Piper’s senior project (Piper et. al 1989). This spreadsheet is very similar in format to the FORSEE spreadsheet, but includes only data gathered in 1989. It is essentially a digital version of Piper’s 1989 inventory complete in one spreadsheet. Relevant data from this spreadsheet has been extrapolated onto the FORSEE spreadsheet, but this one is the complete fieldwork associated with the 1989 senior project inventory.

Verification Spreadsheet³

Since our effort to sort through all the 1989 data is so complex and difficult to follow, we decided to create a third spreadsheet to aid the future data user in establishing confidence in selecting sample populations. This spreadsheet lists the original source of each 1989 plot, and several verification fields for each plot included. The more fields that are checked off establish confidence that the data has been verified in more sources. Be aware that many of the plots we received in digital format did not have dates associated with them and did not have hard copies within the 1989 report (Piper et. al, 1989) Appendix. It is all good data, but use discretion when basing decisions on or modeling with plots that have minimal verification. This spreadsheet includes every plot we have tracked down within the 1989 dataset, according to the report, for a grand total of 69 plots.

² Located on Project Disc. Senior Project Folder\Spreadsheets\89 Swanton Data
³ Located on Project Disc. Senior Project Folder\Spreadsheets\Verification Spreadsheet
Spreadsheet Procedures and General Layout

Plot data was digitally copied from excel spreadsheets located on the NRM department server and faculty hard drives\textsuperscript{4} into the FORSEE spreadsheet for the 1997, 1999, 2003, and 2008 CFI datasets. The 2010 post-fire mortality assessment was taken from raw field sheets, and the 1989 inventory was sourced from several sources including field books, digital data, and the Piper project report. Below, the process of converting each dataset is discussed in greater detail.

Every spreadsheet has the same basic format I.E. a legend tab and a data tab. Every field and its potential values are explained on the legend tab, while the actual data is represented on the data tab. Borderlines are inserted to help the user distinguish individual plots. Additionally, every item has a comments column on the far right which should be noted as we commented on anything we found confusing.

While many of the fields in an inventory were recorded in the same units (such as DBH and tree height), others (such as species and vegetation type classifications) had their own rubric per the dataset they came from. Accordingly, each time we encountered a new rubric, we added an entire column to the spreadsheet and an associated explanation on the legend tab. Fields that are not applicable to a specific dataset are intentionally left blank.

\textsuperscript{4} All digital source CFI data as we received it is included on accompanying project disc in the folder Senior Project Folder\Supporting Documentation\Given Data
Bonner (1997), Auten (1999), and Anderson (2003) CFI Inventories

These data were compiled and formatted into the FORSEE spreadsheet by Christopher Hipkin before we received the spreadsheet. They are all based on the current Swanton coordinate system and were the basis for the hierarchy scheme we used. This scheme includes different points of identification so the future user can sort the data according to their specific needs such as tract, stand, timber type, and coordinates. Additionally, Hipkin assigned individual plot identification numbers which are presented on the spreadsheet and the project map. These data were already converted for us (C. Hipkin, 2010, pers. comm.).

NTMP 2008 CFI Inventory

The 2008 inventory was given to us in a Microsoft Excel file\(^5\). We copied each field over digitally and used the map to verify coordinate locations and determine the plot identification numbers. For plots not numbered, we assigned new plot identification numbers. This dataset was copied directly from the Swanton archives and converted into the FORSEE format.

2010 Post-Fire Mortality Assessment

This dataset is not a complete inventory. It is an addendum to the 2008 and 2003 inventories; no additional tree physical properties were measured. It assumes the tree dimensions of the most recent inventory and is simply updated with a few new indicator criteria. These criteria are an assessment of fire damage to each individual tree and

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\(^5\) Located on project disc Senior Project Folder\Supporting Documentation\Given Data\LC CFI Plot Data 2008
consist of 3 additional fields: whether the tree exhibits basal sprouting, crown sprouting, and the percent live crown remaining. Additionally, each tree’s status was determined and updated to dead or some degree of stress if appropriate; indicated in the status column or the tree comments column. Other qualitative indicators such as disease or damage were updated as well. The 2010 Post-Fire Mortality Assessment was not in digital format yet so we entered its additional fields into the FORSEE database directly from a PDF copy of the original field books.\(^6\)

**Piper et al. (1989)**

We received incomplete data from this senior project in two formats: 3 of the original field books and some Excel 1.X documents located on the department server and faculty hard drives. These excel 1.X documents were converted to be compatible with modern machines by opening them on a 1st generation MacBook and converting them to a compatible format using an older version of Excel\(^7\). 1989 plots from both sources were entered into the 1989 Swanton Data Spreadsheet to provide the NRM department with one complete and homogeneous format for future department use. Replicate plot data was cross referenced between the two sources for confidence establishment, plot identification, and data verification. Replicate plots were then omitted. All 1989 data was digitally copied into the FORSEE database. The verification spreadsheet was created to aid the data user in selecting plots and establishing confidence in them. Again, not all data encompassed in this inventory is actually from 1989. All plots in the FORSEE

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\(^6\) PDF scans of field sheets located on project disc. Senior Project Folder\Supporting Documentation\Given Data\2010 Postfire Mortality Assessment Field Sheets

\(^7\) Converted 1989 Inventory Excel 1.X Documents located on project disc. Senior Project Folder\Supporting Documentation\Given Data\1989 Inventory Converted
spreadsheet have been verified, but some digital and Appendix plot data was dated prior to or after the senior project (Piper et al. 1989, the associated appendices, and Converted Plot Data from Excel 1.X).

**Project CD**

Included in master versions of this report is a multimedia CD with all the digital and GIS data used for processing the project spreadsheets and mapping. The associated GIS database should be compatible with all versions of ArcGIS after version 9.1.3. Included in the appendices is a brief section on how to properly source these layers so they can be used on any computer with GIS software.

Also included is all the raw digital source data that was given to us by the NRM department. Cited inventory and senior project reports have not yet been scanned into digital form and are listed on the works cited page, but not included on the project CD. Figure 2 maps out the location and format of the associated project disc which should be included in all official versions of this report.
FIGURE 2. Senior Project CD Map of Contents

PROJECT CD

SENIOR PROJECT FOLDER

REPORT
Project Report
Project Flowchart

GIS
Senior Project Geodatabase
Maps 1-8 PDFs
Maps 1-8 MXD files (ArcGIS)

SPREADSHEETS
89 Swanton Data
SwtnAllPlotData19oct2010
Verification Spreadsheet

SUPPORTING DOCUMENTATION

HIPKIN
Swanton Inventory Background Maps
Santa Cruz Mtns Project Geodatabase

AUTEN
1997 CFI
CFI Plots and Stand Types Map
Draft Marking Guidelines 2010
Mortality Assessment 2010
Spring 2010 Salvage Slope Stability Letter
Archibald Cruise Report

GIVEN DATA
1989 Inventory Converted
2010 Post-Fire Mortality Assessment
Bonner 1997
LC CFI Plot Data 2008
FIGURE 3. PROJECT FLOWCHART
DISCUSSION

Project Development

The nature of this project altered drastically from the original layout. In its early stages, we examined some different data sets which had been done independently as senior projects on the ranch (Bonner 1997, Cross 1996), specifically within the Little Creek drainage. From these the intent was to actually go out into the field, relocate, and re-measure plots from these projects to capture the effects of the multiple disturbances. These can include anything from past logging and silvicultural entries, landslides, or wildfire. It was determined through consultation with the mensuration faculty (N. H. Pillsbury and S. Gill, 2010, pers. comm.) of the department that:

1. The probability of finding the plot centers after the fire and correctly identifying plot trees was too variable with too much room for error to be statistically acceptable and have enough weight in a peer reviewed study.
2. The sample size in question would have been too small in both terms of acreage and portion of the stand sampled.
3. Not enough independent stand exams had been done consistently to isolate the impacts of the individual disturbances.

In order to remedy this, we elected to extrapolate the project to take advantage of the full CFI system that had been installed on the ranch. By using CFI data, we have a higher degree of confidence in our data because it is replicated, and easy to field check and
locate plots. Within CFI, trees are individually identified and plot centers have been consistent since the system was established (Tree numbers within the 1989 inventory are NOT the official Tree ID numbers under CFI). It also enabled us to have a larger sample size and area to support an in depth study and provided a sizeable number of plots that have consistently and systematically been measured throughout the disturbance regimes.

The main leg of the project consisted of gathering all the appropriate CFI and inventory data and getting it all into the same format. This was accomplished through the various means previously discussed and involved converting and standardizing plot data from the department hard drive, old apple Excel files, and raw field books. While the actual CFI datasets were relatively consistent in format, the 1989 inventory was independent of the CFI system and required a much more in depth approach with regard to plot locations, verification, and whether or not it would match up with the more recent CFI exams.

**Issues and Concerns**

It is a big step to have all of Swanton’s timber inventory data in one place, but there are still many issues that will need to be resolved before the data can be utilized to its full potential. Through the process of converting the data, we have identified some of these issues and feel it necessary to disclose them to the future data user.

Most of our concerns rest with how well the 1989 independent inventory matches up with the current CFI system. It is important to note that Piper’s senior project was conducted before the official establishment of the CFI system, but theoretically it is on the same coordinates. We converted the plot coordinates to reflect the current coordinate
system, but this should not provoke the assumption that these are exactly the same plots. In 1989, Piper et al. indicated that all plots had their centers marked in the report, but Bonner 1997, reported that his crew was unable to find several plot centers. Additionally some of the digital source data did not have dates on the spreadsheets and no properties that differentiated plots between Piper’s data and previous/subsequent class projects.

The 1989 inventory is a representative dataset, however, and should not be discounted even if it does not match up with the current CFI system. It can be homogenized to estimate what the stands looked like historically and can be qualitatively compared to more recent plots in the same area. But as far as matching up perfectly with the CFI system, we predict that there is too much variability and margin for error.

Additionally, there are some other issues that will need to be addressed within the FORSEE spreadsheet. Anything we found questionable or still needing attention has been highlighted in yellow. This includes values from the raw data that do not make sense (such as a 5” DBH tree being 180’ in height) and tree number designations that still need a formatting rubric in order for the FORSEE software to process them. We left these items highlighted for the future data user to make the decision how they would like to classify the data. Since much of the data was copied from the field format, it is only as good as the notes in the field books which sometimes can be unclear. Sometimes, a plot was missing data from a specific column or row so we left these fields blank. Between some of the separate inventories, rubrics and field values differ, so in many cases there are multiple columns for the same field. However, any data that is unclear, questionable, missing, or requiring immediate user attention is highlighted in the spreadsheet. This data
is very valuable but will require the utmost attention to detail in order to clearly and accurately depict the history of Swanton’s timber resources.

**Strengths and Weaknesses**

The value of 21 years of inventory data is not to be underestimated. This data has long been overdue in standardization and now that it is in the same format, has great weight and potential in representing a window of change in the forest dynamics at Swanton Pacific Ranch. While much of the data was in different formats, the CFI system has identified individual trees which have been relatively consistently and systematically measured through several disturbances. This is particularly valuable from Swanton as it is one of very few detailed historical datasets within the southern sub-district of the coast district redwood forests.

Some other factors need to be considered when analyzing these datasets. Traditionally, Swanton Pacific Ranch has been an outdoor laboratory for the NRM department and therefore much of the data has been collected by students, interns, and those learning the field techniques of forestry, sometimes under minimal supervision. It has not, for the most part, been collected by industry professionals. Also the formats and specific measurement specifications differed slightly between inventories. General properties do seem to match up well, but some fields display inconsistencies such as changing species, tree DBH’s decreasing through time, or measurements taken in different units (inches VS millimeters in radial growth measurements). Finally, plots are located by distance and bearing and plot centers are not always found as indicated by previous reports. There is likely some surveying error in the precise location of plot
centers, particularly between the 1989 inventory and the rest of the current CFI system.
This does not discredit the data, but some care should be taken when comparing this data
to the actual CFI datasets. It should be adequate for general comparison purposes.
CONCLUSION

Implications for the Data User/Disclaimer

All our confidences and concerns with this data have been expressed within the preceding report. We urge the user to consider these things carefully and to think critically when analyzing the content. We are very confident in the strength of this database as we have verified it through several different means, but the uncertainties will need to be absorbed and expressed, particularly in the academic and professional world. We have taken the utmost care to be as transparent as possible in order to maintain the integrity of this database, but keep in mind, analysis and conclusions are only as good as source data.

Future

We hope that this standardization aids the department greatly in the management of Swanton Pacific Ranch and that this new dataset facilitates further projects and improvements on data management at the ranch. Accordingly we believe there are several items on the immediate horizon that could greatly expand the scope of this project and make this data even more valuable.

It is our hope that Swanton Pacific Ranch will utilize this FORSEE spreadsheet and collaborate with the NRM department in order to define and standardize data management protocols for the CFI system at Swanton. This would include evaluating the
specific field protocols to incorporate relevant data pertinent to long term ranch management, standardizing a format or database for CFI data to be kept and consistently updated, and the ability to summarize and generate reports on current timber resources to aid future harvests and management activities. While our project provides the means for much research, the primary objective should be to put this database into a clean digital format such as Microsoft Access.

Twenty one years of inventory data provides us with an opportunity to conduct some in depth case studies such as Dr. Piirto’s critical review. This effort will also help facilitate the calibration of the FORSEE software to more accurately represent the variability of redwood stands within the Southern sub-district of the Coast District according to the Forest Practice Rules. Combined with other documentation such as past THPs, GIS (Geographical Information Systems) layers, and other past senior projects, this comprehensive data has great potential for further modeling and multidisciplinary studies.

**Closing Remarks**

There is much to learn from this project. Establishing a CFI system for a forest is not an easy task, particularly with the task of seeing into the future and creating measurement specifications that will suit both current and future data uses. It is worth the effort however, especially in a situation like that of Swanton where the data will be used not only for assisting the forest manager in present activity, but will slowly be built into a historical database with the intent of research and critical review. It is also of the utmost importance to clearly establish measurement specifications and assure that they are
followed in a consistent manner. Kept in a secure and accessible location, this data should be continually maintained and updated as necessary to keep up with changing technology. While very valuable, this project might not have been necessary with proper data management over the history of the ranch, but when establishing CFI systems, these variables are very difficult to project. We can learn from this and present it as an example to those who might be managing forest inventory data in the future.

Now that the data is in the same format and location, it is of great value to the ranch and the NRM department and provides us the means to see how our resources have changed through time, how our management decisions have impacted them, and provides us with a basis to make future decisions. There is great opportunity with this newly compiled database and it is our hope, as those who took the time to compile it, that the department will take full advantage.
WORKS CITED


Big Creek Lumber Company, 1991. *FOREST MANAGEMENT PLAN for the SWANTON PACIFIC RANCH*. Natural Resources Management Department, California Polytechnic State University San Luis Obispo, CA

Bonner, L. E., 1998. *CFI Inventory Report for the Swanton Pacific Ranch*. Senior Project, Natural Resources Management Department, California Polytechnic State University San Luis Obispo, CA


Maskrey, T., and J. Reimer, 1993. *Implementation of Single Coordinate System for Swanton Pacific Ranch*. Senior Project, Natural Resources Management Department, California Polytechnic State University San Luis Obispo, CA


Todd, J. R.. 1988. *Vegetative Type Map for Swanton Pacific Ranch*. Senior Project, Natural Resources Management Department, California Polytechnic State University San Luis Obispo, CA
APPENDICES
APPENDIX A: MAPS
Map 1: Plot ID and Coordinate Location at Swanton Pacific Ranch

Legend

- **NTMP Plot Type**
  - RW
  - RW Smith Stand
  - Benchmark 1238N
  - No Data
  - MP
  - MP Plantation

- **NTMP Timber Type**
  - RW
  - RW Site II
  - RW Site IV
  - RW Smith
  - Spr_Stream

Map drawn by Dominic Ali, 16 Dec 2010
Scale 1:24000, Contour Interval 40 ft
Map 2. Plot Repetition and Entry by Inventory Year at Swanton Pacific Ranch

Map Created by Dominic Ali, Dec 17 2010. Scale 1:15000. Contour Interval is 80 ft.
Map 3. 1989 Inventory and G&Y Class Plot Locations (Piper et al. 1989)

Map 4. 1997 CFI Plot Locations (Bonner 1997)
Map 7. 2008 NTMP CFI Plot Locations (Auten 2008)

Legends:
- PMFA CFI Plot (35)
- Stream
- Swanton Boundary

Map Created by Dominic Ali, 22 Dec 2010.
Scale 1:20000. Contour interval is 80 ft.

Map 8. 2010 Post-fire Mortality Assessment Plots (Auten 2010)

Legend:
- PMFA CFI Plot (78)
- Stream
- Swanton Boundary

Lockheed Fire Burn Severity
- High
- Moderate
- Low

Map Created by Dominic Ali, 22 Dec 2010.
Scale 1:20000. Contour interval is 80 ft.
PMFA = Post-Fire Mortality Assessment
APPENDIX B: GIS INFORMATION
SOME NOTES ON FEATURE CLASS AND LAYER PROPERTIES

Often to the untrained or infrequent GIS user, files can be very difficult to manage and keep track of. Though necessary precautions were taken in this project to minimize file referencing issues, there is potential for some of the layers to not be properly referenced.

The general idea was to locate all the referenced GIS data in a special folder called a Geodatabase. This file is specifically designed to store and organize GIS data in package files called feature classes for vector data, and grid or image files for raster data. The geodatabase is designed to be used in and read by ArcCatalog, a file management attachment that should be included in your ArcGIS software package. Do not attempt to manage files using windows explorer as it lacks the capacity to recognize these feature classes. Always use ArcCatalog when managing GIS data.

A feature class is a type or combination of types of geometry namely points, lines, or polygons with geographical or coordinate location. It can have several reference files including tables and coloring schemes. In essence, a feature class is actually several files that are interrelated. ArcCatalog automatically groups them for the user so that when anything is edited or moved, the entire package is changed accordingly. In explorer, it is near impossible and very confusing to identify which files belong to a specific feature class. They are the basic component of spatial data representation in GIS software.

A layer is a modified representation of a feature class. It simply references a feature class in its parent location and displays it in a specified format. In the context of this project, our layers reference our feature classes and raster data from the geodatabase. We clarified some of the feature classes and formatted them to display by fields that would be easier to understand to the user. These updates were exported to the layers file. You can add layers to ArcMap just like feature classes and they will reflect the changes you have made. Layers are convenient because you can have multiple layers referencing one
feature class.

One last note is that you may have issues with your new GIS documents referencing file locations from our databases at Cal Poly. This issue is represented by red explanation points next to the layer name. To reset the data source, right click on the layer name, choose data and repair data source. From here you can navigate to the proper location which in this case would be in the project folder under the Senior Project Geodatabase.

Comparison of feature classes in Windows Explorer and ArcCatalog

Notice that in ArcCatalog, the feature classes are organized by name and each one is a complete package. When compared to Explorer, the separate components are loose in the folder and will not be as easy to read or recognize as in the second picture. Notice that the files are all named in programming language designed for ArcCatalog and the file type is unspecified and unable to be recognized by Windows.

Another potentially confusing terminology issue that you will come across are the terms shapefile and feature class. These two items are essentially the same thing with one minor difference. A shapefile is a vector file that stands on its own in any location, while a feature class is the same thing but locked in a geodatabase. They both can
only be recognized by ArcGIS software and will be difficult to work with in windows.

**File Types and Descriptions in ArcGIS**

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<th>FILE TYPE</th>
<th>DESIGNATION/DESCRIPTION</th>
<th>ICON</th>
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<tbody>
<tr>
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<td>Feature class consisting of point vector data</td>
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<tr>
<td>Line Feature Class</td>
<td>Feature class consisting of line and polyline vector data</td>
<td><img src="image2.png" alt="Icon" /></td>
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<tr>
<td>Polygon Feature Class</td>
<td>Feature class consisting of polygon vector data</td>
<td><img src="image3.png" alt="Icon" /></td>
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<tr>
<td>Geodatabase</td>
<td>.gdb Specialized folder, holds, protects, and compiles feature classes</td>
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</tr>
<tr>
<td>Raster</td>
<td>.img Raster data file</td>
<td><img src="image5.png" alt="Icon" /></td>
</tr>
<tr>
<td>Layers (group, polygon, raster)</td>
<td>.lyr References feature classes, rasters, or groupings of either</td>
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<tr>
<td>ArcMap File</td>
<td>.mxd ArcMap map document format</td>
<td><img src="image7.png" alt="Icon" /></td>
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