

**Growing the Forest Backwards
Virtual Prehistory on the North Fork of the Eel River**

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All tables, maps, and graphs were scanned and follow the text]**

Introduction

Beginning in 1985, and for a period of about 4 years, one of the authors (Keter) collected data on vegetation associations and their distribution across the landscape within the North Fork of the Eel River Basin, located in southwestern Trinity County. A summary of this research, *Environmental History and Cultural Ecology of the North Fork of the Eel River Basin, California* (Keter), was published in 1995. The purpose of this paper is to present the steps that have been taken over the last year to link the previously recorded vegetation-type distribution data with a new and more refined vegetation classification system developed by Forest Service ecologists and to illustrate this data geographically using GIS (geographic information systems). Using criteria summarized in the next section of this paper, the authors have developed a series of maps that display both the current distribution of vegetation-types within the basin and the distribution of these same vegetation-types prior to the beginning of the historic period.

Part I

In the Beginning: A Summary of Past Research

Over the last decade numerous publications have documented the fact that since the beginning of the historic era the distribution of many plant species across the California landscape has changed dramatically as a result of human land-use activities. In many regions the distribution of various vegetation types is today very different from that of the prehistoric era. The purpose of the research project initiated in 1985 was to characterize in quantitative terms just how much change has taken place in the distribution of various vegetation-types since the beginning of the historic period within the North Fork of the Eel River basin (Map 1).

The area selected for the study was that portion of the North Fork basin north of the confluence of Hull's Creek and the North Fork of the Eel River (see Map 2). This area was chosen for study because it consists primarily of public lands, and even today is remote and relatively undeveloped in comparison with other drainages in the region (there are still no bridges crossing the North Fork within the study area).

After reviewing ethnographical and historical data on past land-use activities within the North Fork basin, Keter (1995:5-11) concluded that during the prehistoric era, anthropogenic fire was a significant factor influencing the distribution of vegetation. Further, that land-use practices during the historic period (including the lack of wildland fires) have influenced significantly the distribution of various tree species (particularly white oak, black oak, and Douglas-fir) within the basin.

Initial Research: 1985-1989

During the late 1980s, a number of archaeological surveys were undertaken within the research area. At that time data were also recorded on the species of vegetation and their distribution across the landscape. The results of this research were published in 1995 (Keter 1995). The remainder of this section consists of excerpts from this book outlining how the vegetation data were collected and the assumptions used in classifying vegetation.

Changes in the extent and distribution of vegetation were quantified through the use of a system of “polygons” developed by the Land Management Planning Department of the Forest Service, which classifies and maps vegetation distributions on a series of topographical maps. The irregularly shaped areas vary in size from about 2 to 250 acres. Most, however, average about 20 to 40 acres. For example, the Long Ridge 7.5 minute U.S. Geological Survey map is divided into 1,098 polygons, and the entire research area contains approximately 5,000 polygons.

For each polygon, specific information is recorded in a database about that unit of land. For forested areas, the timber type and relative age are generated through aerial photographs that delineate crown closure, tree type, and stand density. Under this system, Douglas-fir stands can be classified as seedlings and saplings, pole timber, saw timber, large saw timber (mature), and large old-growth.

For this study, polygons were further classified with on-the-ground surveys by one of the authors (Keter) that recorded such characteristics as the presence or absence of dead or dying oak (white oak and black oak) under the closed canopies of the stands of Douglas-fir, subdominant species of vegetation, and other vegetation characteristics. Vegetation type was then recorded by polygon for both the years 1985 and 1865. The year 1985 was established as the baseline for entering current vegetation associations (the year the study began), and the year 1865 was selected as the historic baseline year. The year 1865 was chosen because it marked the point at which there was a major shift in land-use activities in the region. Until 1864 some of the local Lassik and Wailaki continued to inhabit the North Fork basin and maintained a semblance of traditional subsistence activities. In the fall of that year, the surviving Indians in the region were removed to the Round Valley Indian Reservation (Keter 1990:15).

U.S. Geological Survey maps and polygon maps were carried in the field and each unit of land was classified during the course of archaeological surveys. The presence of factors indicating a previous oak woodland area or evidence that grasslands (locally referred to as glades) had been invaded by trees were noted along with current vegetation type. Also noted was whether the stands of Douglas-fir were comprised of old-growth, mature, pole-sized, or younger even-aged trees. These data were then compared with the polygon database for the respective unit of land to confirm the relative accuracy of the vegetation description. Next data were entered on a spread sheet; for each polygon a vegetation description for 1985 (the base year of the study) was

recorded. From field data, each polygon was then assigned a vegetation classification for the year 1865 on the basis of the assumptions outlined below.

Vegetation Classification Categories

The major vegetation classifications are presented below. These classifications were further subdivided to denote associated species and, in the case of Douglas-fir, to denote old-growth, mature, and immature stands of trees. For example, a polygon consisting of oak woodland with small Douglas-fir invading the stand, but not yet over-growing the oak, would be classified as *Wdf*. An oak stand with manzanita and other brush species as an understory would be classified as *Wb*. In this way, a finer distinction could be made between vegetation types. [See Appendix 1 (Keter 1995) for a complete listing of vegetation types.]

The major vegetation classification categories are as follows:

- * Brushlands Areas of brush, xeric aspects with limited vegetation, areas of poor soils
- * Mixed Conifer Areas where conifer species other than Douglas-fir predominate (uncommon)
- * Grasslands Areas where grasslands predominate (savanna, oak savanna)
- * Riparian Areas of stream side vegetation (willow, alder)
- * Oak Woodland Areas where sub-dominant associates include Douglas-fir and ponderosa pine
- * Douglas-fir Fir predominate and are invading and/or over growing oak woodlands
- * Established Douglas-fir stands >120 years of age baseline 1985
(No observable stands displaying characteristics of old growth)

Assumptions in Classifying Vegetation Types

As noted elsewhere in this study [Keter 1995], a number of factors have influenced changes to the environment within the North Fork basin since 1865. These factors include:

- * Cessation of intensive burning by aboriginal groups
- * Intensive grazing and over-grazing by livestock and feral pigs
- * Historic patterns of settlement
- * Emphasis on commercial timber growth and the exploitation of timber resources
- * Suppression of wildland fires since 1905 when the Forest Service took over management of this region

For this study, the most relevant information consists of the acreage and ages of conifer stands in comparison with those of grasslands and oak woodland areas. During on-the-ground surveys, a

number of indicators, as discussed below, permitted classification of the vegetation for 1865.

It is obvious, even to the casual observer, that the oak woodlands and the Douglas-fir within the basin have undergone profound changes in distribution since 1865. These changes are relatively easy to quantify in the field. Within the even-aged stands of Douglas-fir that have overgrown the oaks, one can invariably find several old-growth Douglas-fir. These trees have large lower radiating branches, evidence that they grew in a more open environment with little intra-species competition. After cessation of burning, these trees became the seed source for today's even-aged stands. The oaks provided shade that conserved the moisture content of the top layer of soils, allowing the Douglas-fir seedlings to become established. When the Douglas-fir grew above the oaks and shaded them out, the oaks began to die. It should also be noted that within many of the young Douglas-fir stands there are a few old-growth ponderosa pine. These trees are not shade-tolerant and cannot become established under a dense canopy. They provide additional evidence that a particular area was more open prior to 1865.

In the research area, most of the private lands were acquired under the Forest Homestead Act of 1906 and the National Forest Indian Allotment Act of 1910. One of the stipulations of both Acts was that the land be of agricultural value and contain no stands of commercial timber. Forest Service files (Supervisor's Office, Eureka) contain a majority of the homestead applications for this area, complete with a verbal description of the vegetation and a color-coded map of the vegetation types and their distributions on each 160-acre parcel. It is clear from these reports that the parcels contained almost no conifer stands. There may have been some stands of immature Douglas-fir invading oak woodland areas as evidenced by the recently logged early mature stands (under 100-120 years old) on some areas of the private property. [Many of the original private parcels were bought up by the Twin Harbors Timber Company.]

It should also be noted that many of the original land surveys conducted in the late 19th century by the General Land Office (GLO) used oak trees as bearing or corner markers. Recent land surveys have found many of these trees dead or dying within stands of Douglas-fir (personal communication with Larry Walter, Land Surveyor, USDA Forest Service).

While conifer stands and the oak woodlands were relatively easy to classify, other vegetation associations were more problematic. For example, throughout the North Fork basin there are areas of serpentine soils, laterite soils (mostly in the Red Mountain area), and exposed rock or shallow soils (called "roughs" locally) with their own unique vegetation associations. These associations were considered to have changed little over time because soil type is a limiting factor and many of these areas are on south facing slopes. It is likely, however, that vegetation growth is somewhat more dense today because of lack of fire.

These areas appear to have unique vegetation communities that probably existed prior to 1865. In some locations, however, invasion of brushy areas by Douglas-fir took place. For example, in the Lousy Creek drainage some Douglas-fir had invaded an area that was formerly comprised of

manzanita, the manzanita were dead and in the process of decaying because of the lack of sunlight under the even-aged fir canopy. [In this area, manzanita is an early seral invader known to dominate on sites after hot burning fires (personal communication with Tom Jimerson, Ecologist, USDA Forest Service).]

Although the species composition has changed dramatically since 1865, it appears that over much of the basin, the savanna grasslands and oak savanna (where the number of oaks per acre is very low) have been resistant to the invasion of Douglas-fir. The reason for this stability is that the grasslands rapidly reduce moisture content in the soils near the surface (the opposite effect is true for deeper soils), preventing the establishment of Douglas-fir seedlings. In this region, availability of soil moisture rather than the amount of precipitation, nutrients, light, or temperature are the primary components of forest formation (Barbour and Major 1977:367). [It should also be noted that in this region some oak woodland and oak savanna sites have shallow skeletal soils that are not suitable for the establishment of Douglas-fir. In these areas, stands of white oak are the potential climax vegetation type (personal communication with Tom Jimerson, Ecologist, USDA Forest Service).]

Evidence of the importance of soil moisture to Douglas-fir growth can be seen on some of the local private lands, where pole-sized timber that invaded the oak woodlands has already been harvested. In these areas, Douglas-fir have a low rate of natural regeneration despite adequate soils. With no oak canopy (it died out during the crown closure of the Douglas-fir) to conserve soil moisture in the top 8-12 inches of soils, grasses are now predominating, with some oak regeneration from the base of some of the older trees that survived under the fir canopy.

Age Classification of Douglas-fir

To ensure that the succession of Douglas-fir within the oak woodlands, as discussed in the previous section, occurred after 1865 and that other unknown factors (such as climate) did not incite conifer invasion prior to this date, Keter examined data compiled by Forest Service silviculturalists on the age of potential timber harvest units. Age data on Douglas-fir were examined for three timber sales totaling 1,543 trees within 3,208 acres of timber harvest units located in the research area. Graph 1 clearly demonstrates that the majority of Douglas-fir stands have become established since 1865 (trees were selected for coring in order to determine the average age of a timber harvest unit). Of all stands examined, 80 percent were 120 years old or less.

Most of the even-aged stands of Douglas-fir encountered during field surveys were of the same diameter as those stands with age data (usually about 18-24 inches in diameter). Many stands classified during the on-the-ground surveys were even younger, some 20-50 years old or less. Estimates for younger trees (<25 years) were made by counting whorls (a method used by

foresters to estimate the ages of young trees). In many instances, the stands of younger trees are still under the oak canopy and have not yet begun to shade out and kill the oaks.

An example of young Douglas-fir invading an oak woodland area can be observed on the Russ Homestead (CA-TRI-1000/H). (Most homesteads in this area were abandoned and bought up by a local timber company and are now in the hands of one land holder, a local rancher, or were traded back to the Forest Service). The Russ homestead was not abandoned until the 1930's. Here, the Douglas-fir are very young; most are less than fifty years old and are crowding in around the cabin area. Clearly, these trees have become established since the homestead was abandoned.

It was, in fact, impossible to find *any* stands of Douglas-fir displaying old-growth characteristics within the research area. Old-growth forests are complex and it is often difficult to differentiate them from other stands based on one or two stand structure attributes. In general terms, old-growth Douglas-fir forests are defined as containing a wide range of sizes and ages (including large-diameter trees), a multi-layered canopy, and substantial woody debris in the form of standing snags and logs decomposing on the ground (Bruebaker 1991:18, Jimerson, Bingham et al 1991:2). [For more detailed data on the classification and definition of old-growth Douglas-fir forests in the North Fork basin and adjacent region see Jimerson, Bingham et al 1991.]

Within the North Fork basin, some mature stands exceeding 200 years of age were noted--for example, on the north slopes of Russ Mountain and portions of Packwood Flat. For the most part these mature stands were opportunistic and had probably become established as chance and burning patterns permitted (in areas of topographical shading, for example). To date, no stands displaying the characteristics of an old-growth Douglas-fir forest have been recorded.

Vegetation Study, Results and Conclusions

At this time approximately 23,000 acres within the research area have been classified by vegetation type in accordance with the base years of 1865 and 1985. The research area has been divided into four sub-areas (see Map 2), and surveys have been conducted in each sub-area. Table 1 presents the total acres covered to date within each sub-area.

Table 1

Acres Surveyed in each Sub-Area
(See Map 2)

<u>Sub-Area</u>	<u>Acres Surveyed</u>	<u>Total Acres of Sub-area</u>
1	15,073	27,124

2	2,629	19,009
3	2,690	26,850
4	<u>3,017</u>	<u>19,530</u>
Totals	23,409	92,513

The following discussion is limited to the results of the vegetation surveys in sub-area 1 because this sub-area has been the most completely surveyed--about 55 percent of its area. Sub-area 1 is located to the east of the North Fork and to the south of Rock Creek (see Map 2) and contains about 27,100 acres. Of this total, approximately 19,000 acres are Forest Service lands, 1,100 acres are Bureau of Land Management (BLM) lands, and 7,000 acres are private lands.

Survey results (see Graph 2) suggest that major changes in the extent and distribution of the oak woodlands and Douglas-fir forests have occurred during the last 120 years. On the lands surveyed to date, there has been a six-fold increase in the area of Douglas-fir forest, from 1,051 acres to 6,276 acres. There has been a corresponding and dramatic reduction in the oak woodlands vegetation type, from 6,005 acres in 1865 to only 1,139 acres in 1985. The other vegetation types, the grasslands and brush lands, have remained relatively stable, with some minor reductions (less than 2 percent) being lost to invasion by Douglas-fir. The limited areas of riparian vegetation are not yet reflected for sub-area 1 and no tanoaks (*Lithocarpus densiflorus*) are found in this area. For these reasons, no vegetation category labeled "other" is shown for Graph 2.

Using the land management polygon database for the entire research area and the empirical data cited above for sub-area 1, Keter then projected vegetation association distributions for the entire research area. This projection was accomplished by comparing the 1985 vegetation types recorded in sub-area 1 for this study with the corresponding data from the polygon database. Vegetation associations were then projected for the entire basin on the basis of percentages of the land base occupied by each vegetation type in the land management polygon database. Graph 3 presents this data. The results for the research area as a whole are similar to those for sub-area 1 and demonstrate that significant changes have occurred to the vegetation associations of the entire area since about 1865.

A cursory survey of the remaining portions of the North Fork basin outside the research area (the Hulls Creek drainage and the lower portion of the North Fork drainage) suggests that similar changes to distributions of vegetation types occurred there, although the increase in Douglas-fir is probably not quite as large.

These changes in the extent and distribution of vegetation communities have had a profound influence on the entire ecosystem of the basin. For example, the reduction in the extent of the oak woodlands has also reduced the habitat for various animal populations including deer. Based on the analysis of historic vegetation distributions, it can be concluded that the Indian people of this

region inhabited an environment very different from that which exists today.

Part II

The North Fork Revisited: GIS and the Computer Age

The previous section of this paper, as noted in the introduction, was included in a book on the North Fork basin published in 1995. The reason that research on the distribution of vegetation within the basin was halted in 1989 is due to the fact that map work was being done by hand. It was clear by this time, that the amount of time and effort needed to do the work manually was prohibitive. There were over 40,000 individual fields of data and the five USGS 7.5 minute maps covering the North Fork basin contained about 5,000 LMP polygons. The final output would have required two sets of USGS maps showing vegetation-type distributions--one set for 1985 (base year of the study-- also referred to as “NOW” maps) and a second set for 1865 (the end of the ethnographic period--also referred to as “THEN” maps). This was relatively early in the computer era and GIS (geographic information systems) programs were not yet available to accomplish this work on our rather outdated computer system. Therefore, it was decided at that time to simply hold on to the data and wait until the Forest Service acquired a computer system with GIS capabilities.

The Second Time Around

In 1994, a new computer system was selected by the Forest Service to replace its antiquated Data General system. The new IBM system (mainframe computer) included GIS capabilities. By late 1995, the new system was up and running at a point where it was practical to make an effort to somehow “move” the North Fork polygon data (also referred to as the NF1 veg-type data or NF1 data set) into a GIS environment. (The project area as originally defined in 1985 consisted of the entire North Fork basin north of the confluence of the North Fork of the Eel River with Hulls Creek (Map 2). Because at this time GIS is limited to lands within the National Forest boundary, a small area (about 5,000 acres) along the southern end of the original project area consisting of private and Bureau of Land Management lands was dropped (see Map 3).)

The first step in this renewed effort was to take all of the NF1 veg-type polygon data that had been collected in the original database (residing on a spreadsheet) and translate it into a software program that could be imported into GIS. GIS program applications have the ability to link data tables with geolocational (spatial) data. One of the authors (Busam) then began the process of migrating the NF1 data set over to the new IBM computer system.

First, a database structure was created in Microsoft ACCESS. Next, all of the earlier NF1 data was transferred into this data base. This new database then consisted of all of the NF1 polygon data including polygon number, polygon size (number of acres), and the THEN and NOW veg-

type classifications. Once this data was compiled in an ACCESS data base, it was converted to Dbase and appended to the LMP spatial data on the IBM system using the polygon number as the geographical link.

One other important event related to this research effort occurred during the intervening years (1989-1996) while waiting “patiently” for technology to catch up with the data. Beginning in the early 1990s, Six Rivers National Forest ecologist Tom Jimerson began a process of completely reclassifying the vegetation associations on the Forest. This newly devised method of classifying vegetation is referred to as the Ecosystems Classification System (ECS). ECS differed significantly from the earlier Land Management Planning (LMP) system of classifying vegetation (discussed in the first section of this paper). The earlier system, as obvious from some of the terminology (for example saw-timber, large saw timber), was biased towards obtaining data primarily related to timber management activities. ECS was developed within the context of ecosystems management. This new paradigm, adopted by the Forest Service in the 1990s, mandates that National Forests should conduct management activities and research projects that place an emphasis on maintaining the integrity of ecosystem processes and functions. ECS is part of a larger effort to classify in a consistent manner the vegetation on all National Forest lands within California. ECS describes natural plant communities in a hierarchical manner that includes series, (essentially the dominant vegetative component), subseries (usually understory or subdominant species), and related plant associations. Each hierarchical level is distinguished by a unique set of variables including species composition, soils, site productivity, physiography, and expected response to management activities.

The resolution of ECS can be characterized as more fine grained than the original LMP veg-type polygon system. For this reason, although many of the new ECS polygons and the old LMP polygons were geographically the same, in some instances, ECS further subdivided the LMP polygons into a number of smaller--what can be termed “sub” polygons--resulting in a somewhat more refined mapping of the distribution of vegetation.

The problem we faced, therefore, was how to “join” the NF1 veg-type data recorded and formatted to be integrated with the LMP data set with the new, more refined, ECS data set. We first attempted, with limited success, to create what might be termed a hybrid system combining the rather outdated LMP polygon data with the ECS polygon data by use of the UNION command in ARCEDIT and then linking it to the NF1 data set. We concluded that a more productive and long term solution to the problem would be to abandon the LMP polygon system and adopt the new ECS system by establishing a set of criteria linking it to the NF1 data set.

The idea was that if one could equate or “match” with a high degree of confidence those polygons containing the NOW NF1 veg-type data (equaling about 23,000 acres or nearly a 25% sample of the universe) with the ECS veg-type data, it would follow logically that we could then simply use the ECS data and disregard the LMP data. Further, we hypothesized, that once a link (equating or “matching” the various veg-types between the two systems) was established, it

would then be a simple step to “grow the forest backwards” by applying the same criteria used for the original LMP polygon data (summarized in the first section of this paper) to the ECS data in order to create the THEN vegetation distribution map.

It was also hypothesized that since the NF1 veg-type data already had been collected for nearly 25% of the study area, it might be possible (if we could equate ECS and NF1 veg-type data with a high degree of confidence) to produce a NOW veg-type distribution map for the *entire* project area (in reality an ECS map already existed of the current veg-type distributions but not in a form useable for our purposes). Once this was accomplished, we could then use the ECS data to “grow the forest backwards”--in effect, producing a THEN map displaying the distribution of vegetation across the landscape of the North Fork basin (within the project area) during the late ethnographic period. There were, however, problems to overcome related to:

- * Developing a method to compare and equate (match) the more inclusive NF1 veg-type classifications with the more refined vegetation series and subseries types of ECS
- * A means of comparing spatially the NF1 polygon data with the ECS polygon data to insure we were comparing the same logical unit of land.

A Pivot Table

After a number of false starts involving an attempt to generate maps containing overlays of both the NF1 and ECS vegetation classification systems, it was determined that it was not practical to compare the two data sets visually using maps--it also made a statistical comparison of the number of acres that were classified similarly by the respective systems nearly impossible to accomplish.

At this time, the veg-type polygon data from the NF1 data set and the ECS data set were migrated into an EXCEL pivot table. Essentially, this pivot table provided a means to link and then compare the NF1 veg-type data with the ECS veg-type data and with their respective polygon (spatial) data. This process is illustrated using the following example. The EXCEL pivot table would select all NF1 veg-type polygons classified *Dfo* (Douglas-fir overstory/dead and dying oak understory). It would then select all ECS polygons occupying the same geographic areas displaying the ECS vegetation series and subseries. Continuing the use of the above example, if, for instance, NF1 veg-type polygon 500 was 25 acres in size and the veg-type was *Dfo*, and the same ECS polygon was 25 acres in size and classified *0512* or *0513* (Douglas-fir overstory with white oak and black oak understory respectively) it was considered a match. Although not all polygon data was directly comparable, geographically, due to the differing size of polygons, it was found that when all of the vegetation classifications between the two systems were reconciled, the vast majority of data was comparable both spatially and vegetatively. In the above example, it was found that over 91% of the polygon acreage matched when comparing the NF1 data veg-type

(*Dfo*) with the ECS veg-types (0512 and 0513). The linking of veg-types between the NF1 and ECS data sets was accomplished with the help of Six Rivers National Forest ecologist Bruce Bryan who compiled much of the ECS data for the North Fork basin.

Initially, there were a number of polygons (under approximately 5%) where there was no “match” between the NF1 and ECS data sets. In other words, they were what might be considered “holes” --polygons with no veg-type classification delineated. This occurred where a particular ECS series and subseries (for example, ECS veg-type 0523 Douglas-fir/big leaf maple) had not been matched with a veg-type in the NF1 vegetation data base. The last step in reconciling the data, therefore, was to identify these polygons, and with input from the ecologist, place them within an appropriate NF1 veg-type category. Once this process was complete, a set of NOW and THEN GIS maps were generated for the approximately 23,000 acres of the project area originally surveyed in 1985.

After a careful review of the pivot table data, we determined that by slightly redefining the NF1 veg-type categories, into what might be termed--a more ecologically or botanically correct classification system--compatible with the ECS data set we could indeed create NOW and THEN maps covering the entire project area. For example, the NF1 vegetation-type Brush (B) was changed to Xeric (X) since not only areas of brush, but those area with serpentine soils containing an overstory of jeffrey pine and areas with gray pine were included in this category. The newly defined NF2 veg-type classification system (or NF2 data set) is summarized in Table 2.

The NF2 data set basically collapsed the ECS data into the same broad veg-type categories that were formulated earlier but were modified in order to make more sense ecologically and in order to answer the research questions first posed in 1985. It is worth restating at this time that the original NF1 veg-type data and the newly developed NF2 data set were formulated to answer the research questions posed at the beginning of this study---has the distribution of various vegetation types changed within the basin during the historic period, and has there been an increase in the extent and distribution of Douglas-fir and a corresponding decrease in the extent and distribution of the oak woodlands.

With the above classification system in place, the next step was to again work with ecologist Bruce Bryan. All of the newly formatted NF2 veg-types (Table 2) were compared to the ECS veg-types. Then, each one of the ECS veg-types was “matched” with and placed in the appropriately defined NF2 veg-type category. This newly created NF2 veg-type data set was then used to create the NOW map outlining vegetation distributions within the basin. Table 3 presents a summary of the NOW NF2 data set veg-types and the respective ECS veg-types.

The Final Maps

After generating the final NF2 veg-type data set, the final NF2 NOW map was created in GIS (see Map 4 for a simplified version of the final map). The next step was to compare the results with the earlier NF1 data set (that had used the LMP polygon data set) to see if they were in general agreement. Graph 4 presents this data. [Total acres could not be compared between the NF1 and NF2 data sets since the original NF1 project area (Map 2) was based on a slightly larger (about 5,000 acres) universe.]

The difference in extent of the Brush (B) or Xeric (X) distributions between the two data sets (Graphs 4 and 5) is mostly related to the difference in their slightly different project area definitions--the southern part of the NF1 data set (Map 2) consists of a greater proportion of xeric veg-types. Therefore, that portion of the research area deleted from the NF2 data set (shown on Map3) that was included in the projections for the NF1 data set was predominately xeric vegetation.

The primary discrepancy between the NF1 and NF2 data sets appears to be between the total number of acres classified as oak woodland and grasslands between the two data sets (Graph 4). In discussions with the individuals who classified ECS vegetation types, it became evident that it is likely that this discrepancy resulted when certain oak woodland/grassland areas were first classified under the respective systems. In the North Fork basin, many areas have only a few oaks per acre--under the NF1 system when the number oaks per acre was under about 30 per acre, the polygon was classified as grassland. If there were more than about 30 oaks per acre the polygon was classified as oak woodland. Under the ECS system it appears that in many areas (polygons), grasslands with somewhat fewer than 30 oaks per acre were classified as oak woodland. Graph 5 combines the two veg-types--grasslands and oak woodlands to see how closely the combined totals compare between data sets. Note that when these veg-types are combined, the data sets are very similar in *total* percentage of the grassland and oak woodland veg-types within the project area.

It appears at least part of the discrepancy between the two data sets for the Douglas-fir veg-type distributions can be accounted for in how certain polygons of the oak woodland type were classified. Keter placed all oak woodlands containing a Douglas-fir understory within the oak woodland category while ECS classified this veg-type as Douglas-fir with a shrub-sized canopy closure (0512 or 0513) and white oak or black oak as sub-dominant species (this is because Douglas-fir will come to dominate these stands within a relatively short time).

It should also be noted that the more mesic site polygons (consisting of locations where tan oak and or Douglas-fir predominate) were added to the Douglas-fir type because this veg-type is actually a sub-set of the Douglas-fir type (Graphs 4 and 5). [This veg-type denotes areas with relatively high soil moisture content. Nearly all of these mesic areas are located in the

northwestern portion of the project area and none had been recorded in the original NF1 data set. The reason these vegetation types are identified is to insure that these more mesic locations were identified for formulation of the THEN maps].

Growing the Forest Backwards

Now that the vegetation distributions for the entire basin had been incorporated into the NOW NF2 data set, it was a rather easy step to simply “grow the forest backwards” and create a THEN map (Map 5). We simply applied the same set of criteria and assumptions outlined in the first part of this paper that were developed for the NF1 data set and applied them to the NF2 data set.

To accomplish this, it was again necessary to work closely with ecologist Bruce Bryan to insure that the assumptions used to equate the THEN NF2 veg-types with the ECS veg-types were correct.

Continuing with the use of the example used earlier to illustrate how the NF2 NOW data set was formulated, we first took the NF2 veg-type *Dfo* (Douglas-fir over dead and dying oak) and when the respective ECS polygon contained the classification 0512 or 0513 (Douglas-fir series, white oak or black oak subseries) an additional variable was used to “grow the forest backwards”-- crown closure. Crown closure provides data related to the relative age of a particular stand of trees. All Douglas-fir stands classified by ECS as under 150 years of age (shrub, pole, early mature, mid-mature) with an understory of oak were considered to have been oak woodland in 1865. The NF2 veg-types and “matching” ECS veg-types are presented in Table 4.

The NF2 THEN data set comparisons of the veg-types with the original NF1 data set are illustrated on Graphs 6 and 7. The data sets were combined the same way as the NOW data sets discussed above.

As noted in the earlier discussion related to the NOW maps, the reason that the xeric/brush veg-type varies is based at least in part on the definition of the project area used for the NF1 and NF2 data sets. When Graph 7 combines the oak woodland and grassland veg-types it is clear that there is a strong agreement between the two data sets.

The original research objective of this study, as mentioned earlier, was to develop a set of USGS maps that displayed the current (NOW) and past (THEN) distribution of vegetation associations within the North Fork basin. Originally, the idea was to display vegetation-type distributions on USGS maps. The final maps, however, were produced on a color plotter. As noted earlier, a simplified set of NF2 NOW and THEN maps (Maps 4 and 5) are included with this paper. These maps present only the vegetation distribution data in order to keep them legible at this small scale.

In the future, since this data is georeferenced it *can* be displayed as overlays on USGS maps-- however, at this time, it is merely displayed on NOW and THEN maps of the North Fork basin that contain the outline of the watershed, the North Fork Eel River, and blue-line creeks.

The Future

The purpose of this paper was to provide a summary of the research conducted to date on the distribution of vegetation types both present and past within the North Fork of the Eel River basin. Now that the basic work has been accomplished, future researchers can use this data to provide insights on the dynamic relationship between past human land-use activities and the environment. One of the things that makes the new GIS system so powerful is its ability to relate various kinds of geospatial data. Therefore, we have the ability to link the NF2 data set to other resource data sets or tables including for example information on soils, wildlife, hydrology, and fire history. In addition, the authors are part of a team of Forest Service archaeologists and computer programmers designing a heritage sites data base. This ORACLE database will provide us with the ability to link site record data with the geolocational data presented in this paper. We hope to use the site data to construct various layers of spatial data linking such variables as site location, site function, and tool types. The opportunity to undertake research related to both past human activities as well as environmental trends should provide researchers with new insights into past prehistory and historical environment of the North Fork Basin.

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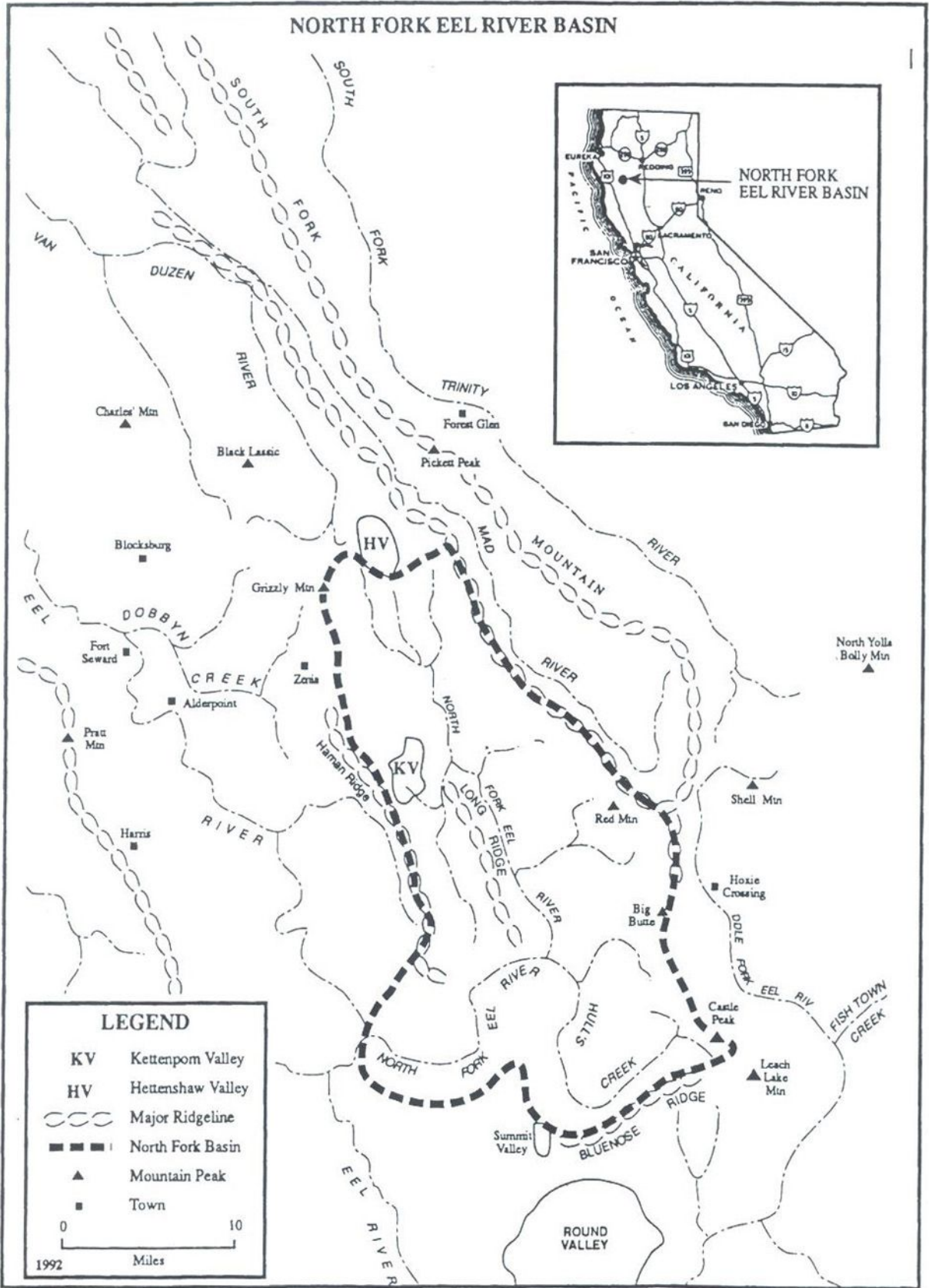
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The authors would like to thank ecologists Thomas M. Jimerson and Bruce Bryan for their help in working with the Ecological Classification vegetation data. We are also grateful to Mike Martischang, Ken Wright, and Denis McKinnon for their help in working with the GIS system and providing critical expertise in linking the North Fork data set to GIS.

Table 2

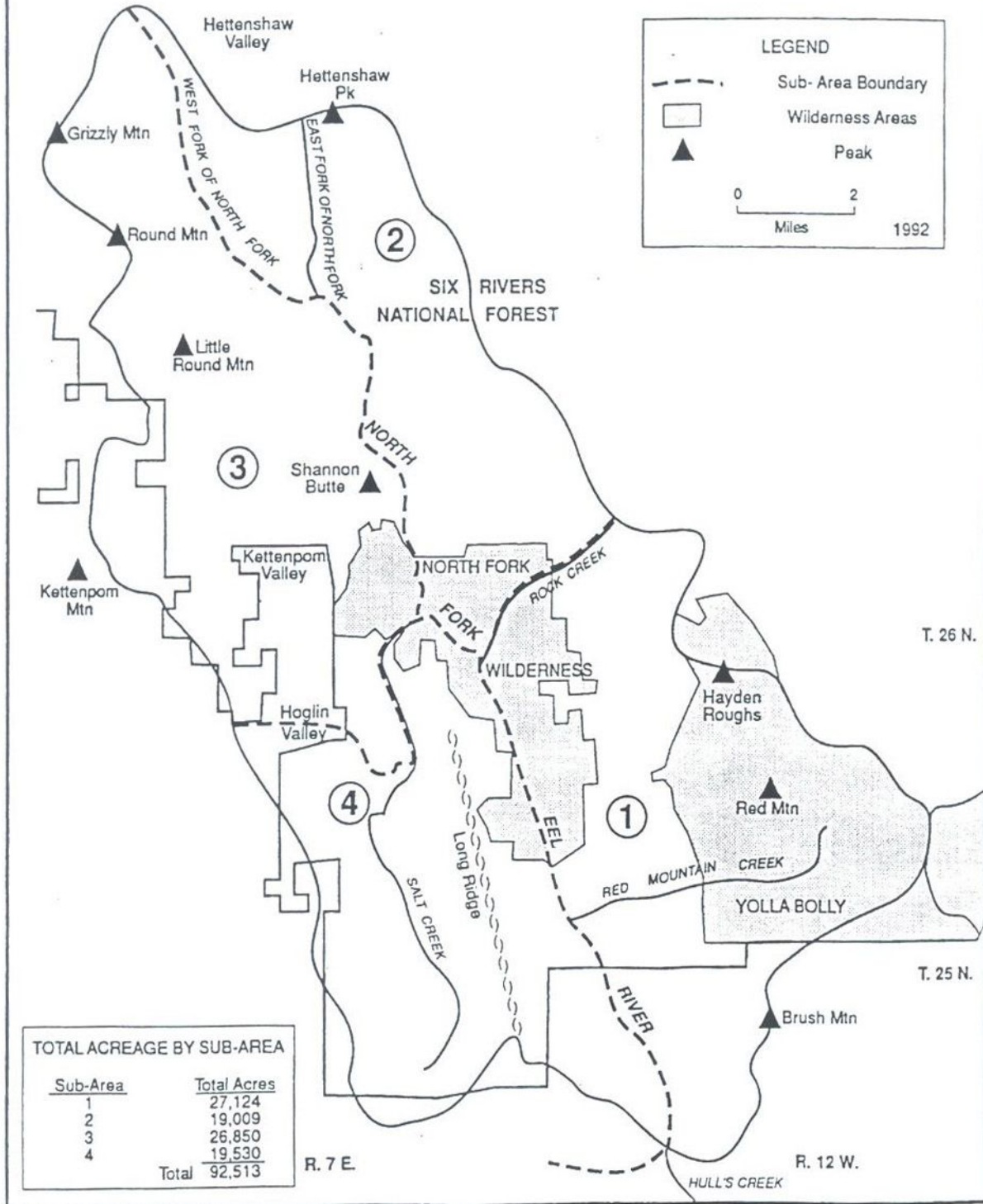
NF2 Major Vegetation Types

NF1	NF2	<u>Reason for change</u>
B Brush	X Xeric	This was modified since soil moisture content and soil type clearly limit the ability of some species to occupy these sites. This permitted all series and subspecies that are Xeric in nature to be grouped here and to dispense with the misleading and somewhat inaccurate classification brush. It also includes areas of limited vegetation because of poor soils and areas of serpentine dominated by jeffrey pine.
OW (Oak woodland)	OW	This classification remained the same and all white and black oak series were placed under this class.
DF	DF	This remained the same for NOW maps--however an additional ECS field of data, seral stage, was needed to classify the age class of the Douglas-fir stands for the THEN maps.
XDF (Douglas-fir)	DF	The X denotes stands of fir that existed prior to 1865. ECS Douglas-fir stands with seral stages classified as old-growth and late mature were selected out of the 05 series denoting stands over 150 years old and classified as DF on THEN maps rather than XDF.
OS (Grasslands)	G	This was changed to equate with the ECS grassland classification. Although there has been some reduction of grasslands to oak woodlands (some grasslands depending on soil type and slope orientation are the seral stage for oak) it is likely that this has not been significant due to the fact nearly all stands of white and black oak appear to be late mature.
T (Tanoak)	M (Mesic)	It was found that certain conditions related to soil moisture content, soils type, and and topographical shading (usually on north facing slopes or steep walled inner gorges along water courses) made it possible to combine several of the ECS veg-types into a mesic classification denoting sites where tanoak, Douglas-fir, big leaf maple, Alder, and pepperwood (bay) tend to dominate sites. Given the more mesic conditions of these sites it is likely that even with burning these species would have dominated these sites during the prehistoric era.
C (Conifer other than Douglas-fir)	C	Mixed conifer--most of these locations were not recorded in the NF1 survey and mapping as no high altitude portions of the basin (generally located in the located in the northwestern portion of the basin) had been as yet surveyed. These areas are for the most part dominated by white fir at higher altitudes and include a very limited number of acres where ponderosa pine tend to dominate. Due to the fact that white fir tend to dominate only above about 4,000' in elevation, it was concluded that although it was probable that there was an increase in the extent of fir density since 1865 most of these areas were in a true fir zone due climatic variables. Evidence from similar sites on South Fork Mountain (located just to the east) suggest that white fir has probably invaded and came to dominate some white oak woodland sites near the upper elevations of their prehistoric distribution. This factor was not accounted for in this model but should be given further consideration. Field studies should be able to confirm or reject this hypothesis. [Total acreage is not significant]

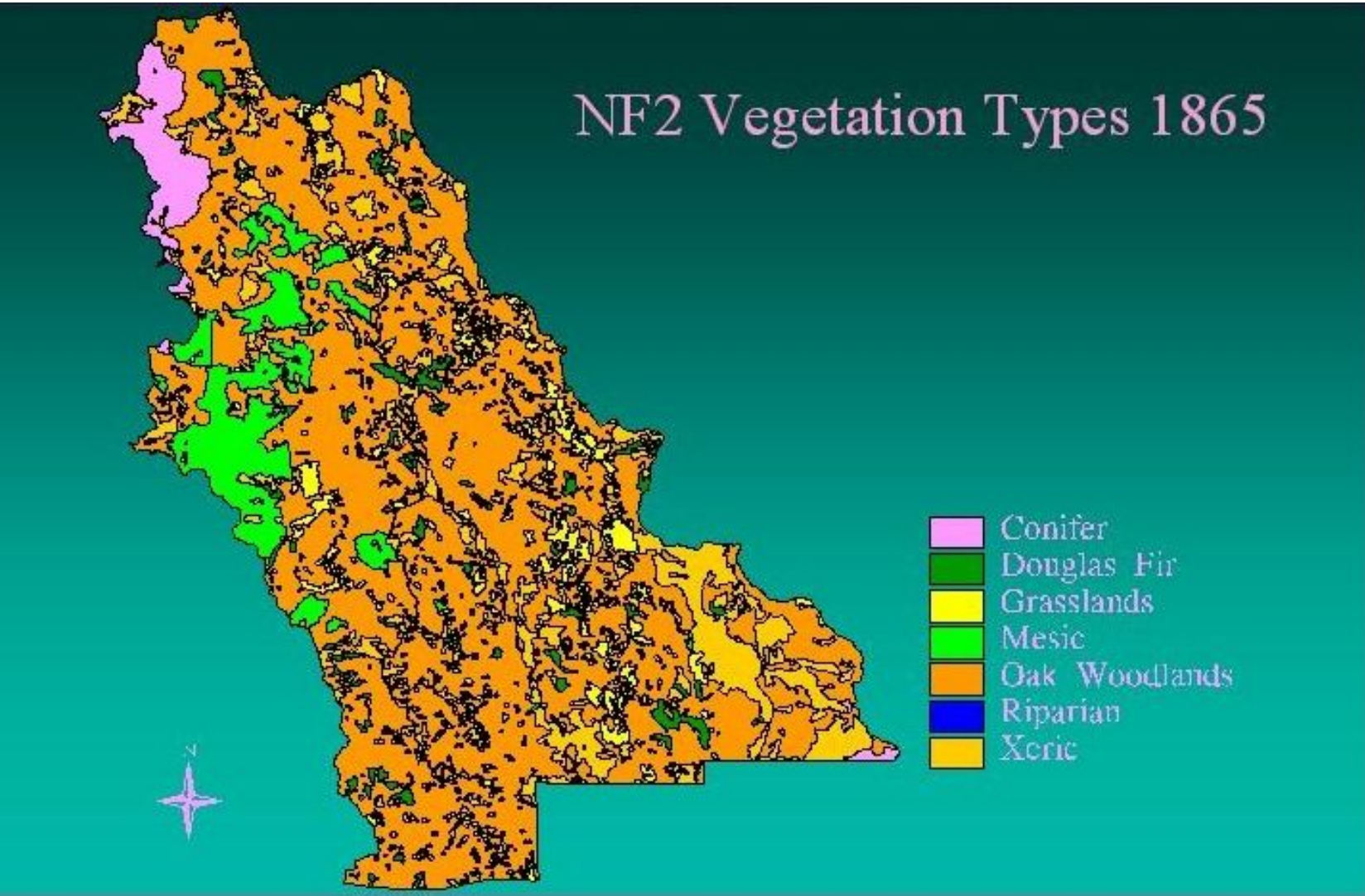


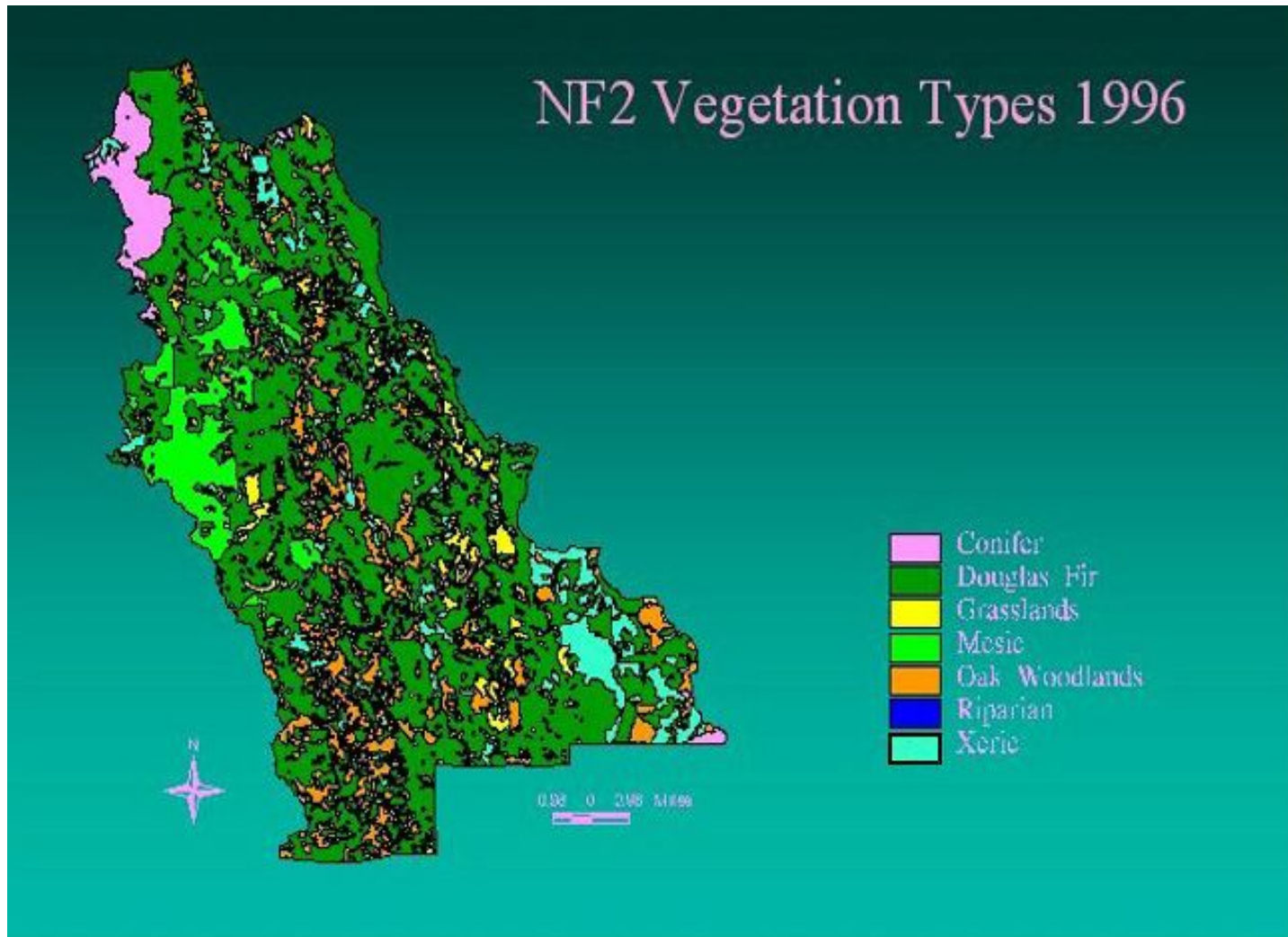
Map 1, North Fork Eel River Basin

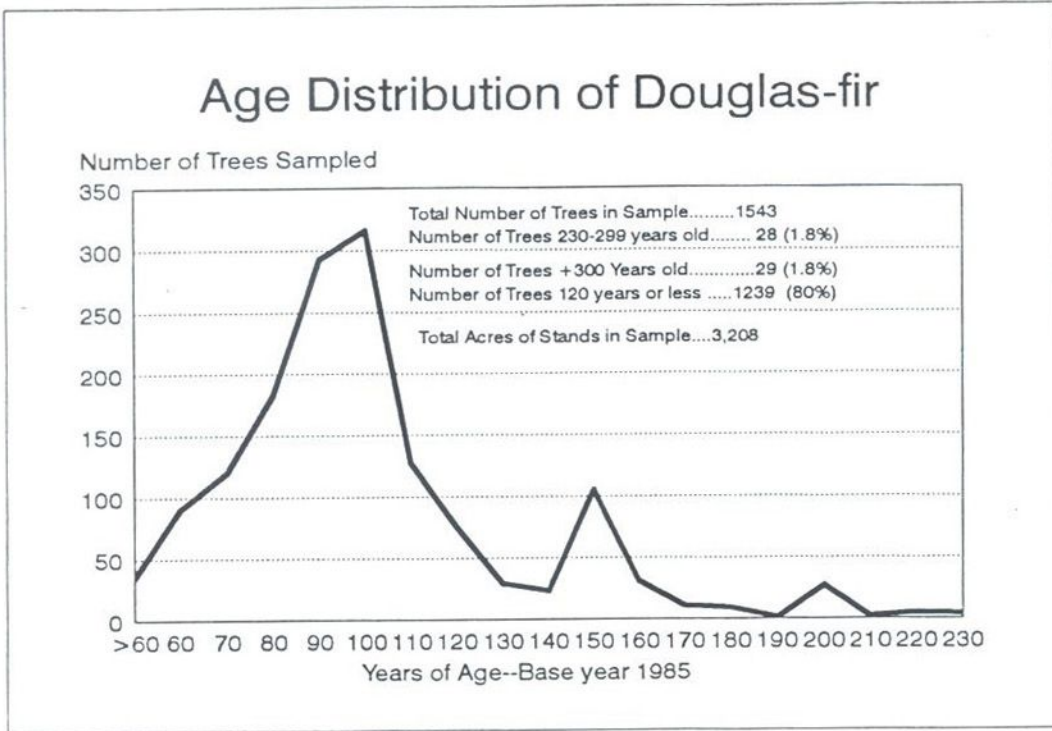
NORTH FORK EEL RIVER VEGETATION STUDY AREAS



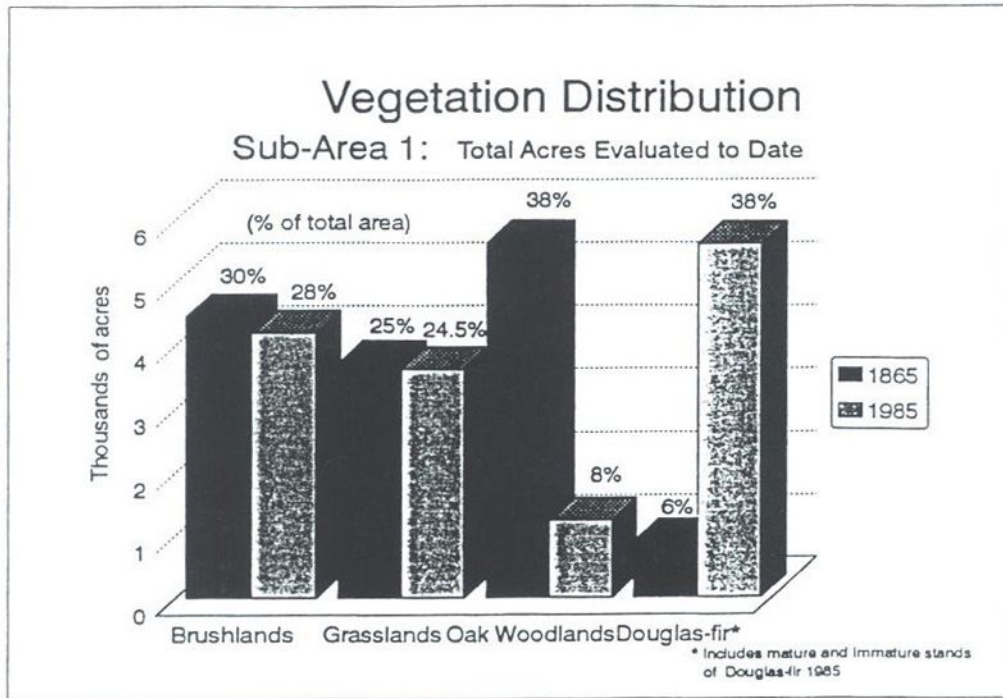
Map 2, North Fork Eel River Vegetation Study Area



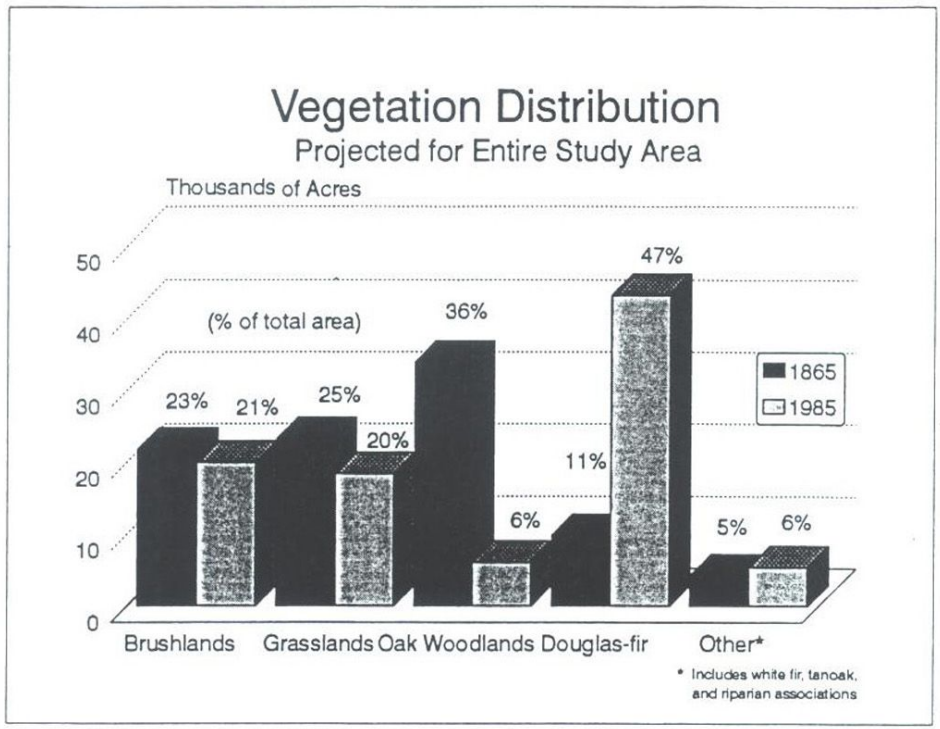




Graph 1, Age Distribution of Douglas-fir

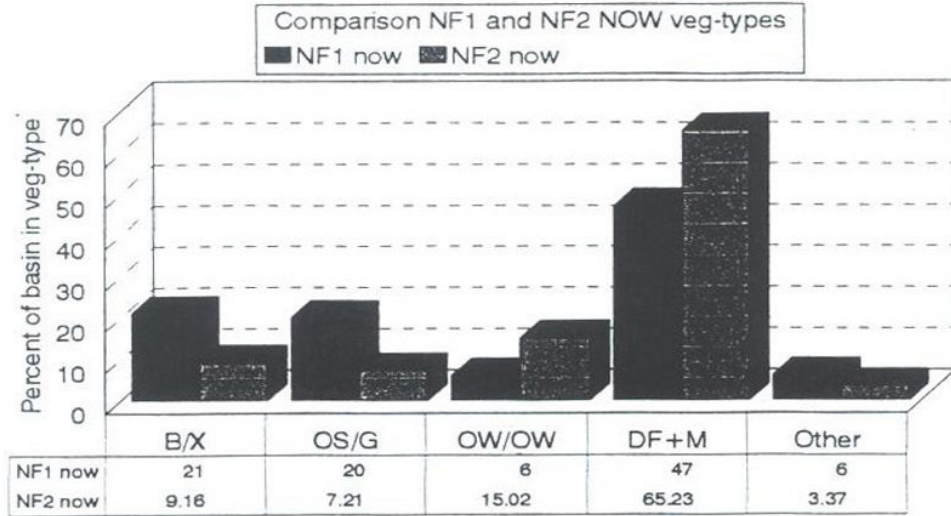


Graph 2, Vegetation Distribution, Sub-area 1

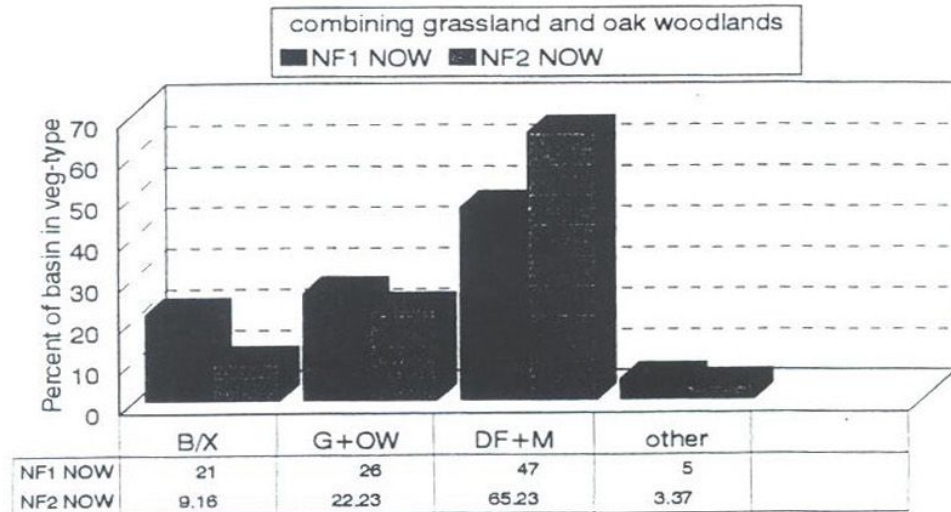


Graph 3, Vegetation Distribution Projected for Entire Study Area.

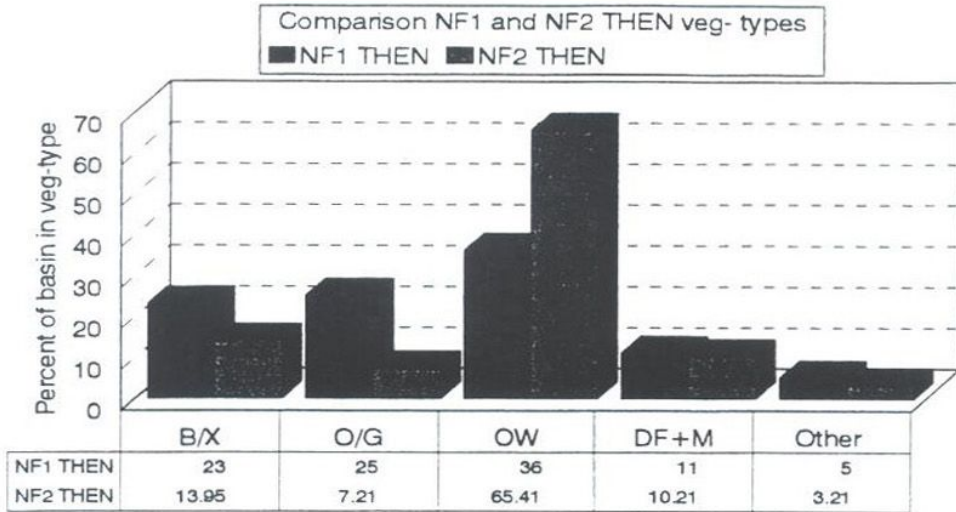
Graph 4



Graph 5



Graph 6



Graph 7

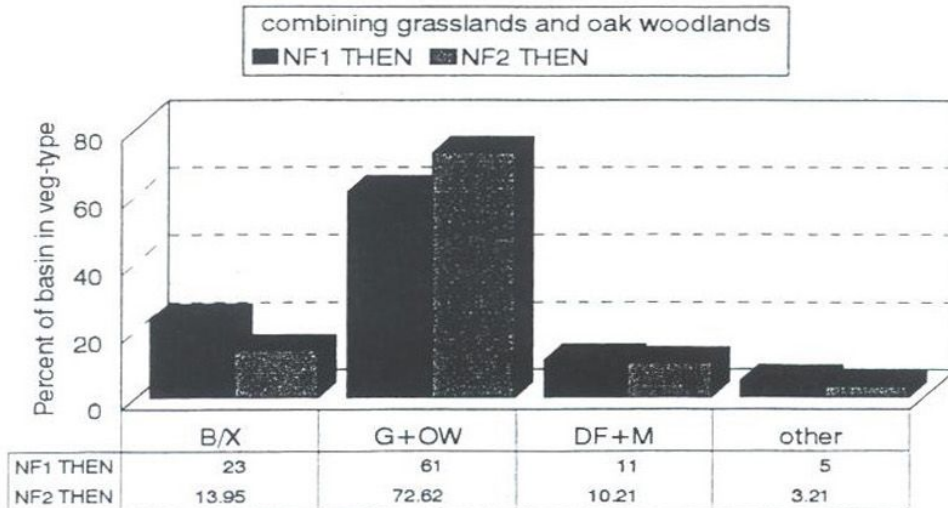


Table 3
Joining North Fork Eel ECS and NF2 Veg-Type
(Now 1996)

Code	Subseries	Type	
g	1100	Grassland	
x	416	Jeffery Pine	Incense Cedar
	1217	White Oak	Canyon Live Oak
	1700	Canyon Live Oak	
	1705	Canyon Live Oak	Douglas Fir
	2000	Digger Pine	
	2012	Digger Pine	White Oak
	2017	Digger Pine	Canyon Live Oak
	2400	Chapparal	
	9900	Non-veg	
	24	Chapparal	
	2004	Digger Pine	Jeffery Pine
c	202	White Fir	
	205	White Fir	Douglas Fir
	212	White Fir	White Oak
	216	White Fir	Incense Cedar
	217	White Fir	Canyon Live Oak
	219	White Fir	Chinquapin
	207	White Fir	Ponderosa Pine
ow	1200	White Oak	
	1205	White Oak	Douglas Fir
	1213	White Oak	Black Oak
	1217	White Oak	Canyon Live Oak
	1233	White Oak	Late Mature
	1300	Black Oak	
	1220	White Oak	Digger Pine
df	507	Douglas Fir	Ponderosa Pine
	512	Douglas Fir	White Oak
	513	Douglas Fir	Black Oak
	517	Douglas Fir	Canyon Live Oak
	520	Douglas Fir	Digger Pine
	713	Ponderosa Pine	Black Oak
	505	Douglas Fir	
	505	Douglas Fir	
	534	Douglas Fir	
	516	Douglas Fir	Incense Cedar
	504	Douglas Fir	Jeffery Pine
	712	Ponderosa Pine	White Oak
m	13	Tan Oak	Black Oak
	0	Tan Oak	
	523	Douglas Fir	Bigleaf Maple
	17	Tan Oak	Canyon Live Oak
r	28	Riparian	
	26	Bog	
	27	Seep	

Table 4
Joining North Fork Eel ECS and NF2 Veg-Types
(then) 1865

Code	Subseries	Type		
x	416	Jeffery Pine	Incense Cedar	
	1700	Canyon Live Oak		
	1705	Canyon Live Oak	Douglas Fir	
	2000	Digger Pine	Tan Oak	
	2012	Digger Pine	White Oak	
	2017	Digger Pine	Canyon Live Oak	
	9900	non-veg		
	0517-EM,MM	Douglas Fir	Canyon Live Oak	
	504	Douglas Fir	Jeffery Pine	
	517	Douglas Fir	Canyon Live Oak	
	520	Douglas Fir	Digger Pine	
	31	Juniper		
	0520-EM,MM	Douglas Fir	Digger Pine	
	24	Chapparal		
	2004	Digger Pine	Jeffery Pine	
c	205	White Fir	Douglas Fir	
	216	White Fir	Incense Cedar	
	219	White Fir	Chinquapin	
	516	Douglas Fir	Incense Cedar	
	207	White Fir	Ponderosa Pine	
	202	White Fir	White Fir	
g	1100	Grassland		
m	13	Black Oak		
	534	Douglas Fir		
	0	Tan Oak		
	510	Douglas Fir	Alder	
	17	Canyon Live Oak		
	523	Douglas Fir	Bigleaf Maple	
	ow	1200	White Oak	
		1205	White Oak	Douglas Fir
		507	Douglas Fir	Ponderosa Pine
		713	Ponderosa Pine	Black Oak
712		Ponderosa Pine	White Oak	
212		White Fir	White Oak	
1213		White Oak	Black Oak	
1217		White Oak	Canyon Live Oak	
1233			White Oak - Late Mature	
1300		Black Oak		
0512-EM,MM		Douglas Fir	White Oak-mid mature early mature	
0513-EM,MM		Douglas Fir	Black Oak-mid mature early mature	
1220	White Oak	Digger Pine		
0507-EM,MM	Douglas Fir	Ponderosa Pine-mid mature early mature		
df	0505-OG,LM	Douglas Fir-	old growth late mature	
	0507-OG,LM	Douglas Fir	Ponderosa-old growth late mature	
	0512-OG,LM	Douglas Fir	White Oak-old growth late mature	
	0513-OG,LM	Douglas Fir	Black Oak-old growth late mature	
	0517-OG,LM	Douglas Fir	Canyon Live Oak-old growth late mature	
	0520-OG,LM	Douglas Fir	Digger Pine-old growth late mature	
	0505-OG,LM	Douglas Fir	Douglas Fir-Old Harvest, Mid Harvest	
r	28	Riparian		

