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The earth's vegetation is part of a web of life in which there are intimate and essential relationships between plants and the earth, between plants and other plants, between plants and animals. Sometimes we have no choice but to disturb these relationships, but we should do so thoughtfully, with full awareness that what we do may have consequences remote in time and place.

Rachel Carson
*Silent Spring*, 1962
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Abstract

The use of phenoxy herbicides is an established practice in industrial forestry, particularly in the Pacific Northwest. Forestry herbicide use in this region has often been controversial. To better understand the spatial patterns of herbicide use and the potential for human health and environmental impacts, a landscape level perspective is necessary.

This study analyzes forestry herbicide use in Lincoln and Benton counties in the northern Oregon Coast Range between 1991 and 1994. Notification records filed with the Oregon Department of Forestry (ODF) were used as the primary data source. Herbicide use was mapped for each county at the section (one square mile) resolution, and a selected area within each county at the 1/4 1/4 section (40 acre) resolution. Database and spreadsheet programs were used to calculate the total acres sprayed per section for this period, and the resulting acreage and location data imported into a Geographic Information System (GIS) for map compilation. A background of forestry herbicide history and use is presented, and mapping methodology is discussed. Data tables and charts indicating various relationships between landowner and acres sprayed were created. Significant variation in the spatial extent of herbicide use in each county was found, as well as variation between landowners, season, and years.
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Introduction

As modern forestry has shifted from tree mining to at least partial replanting of the resource, reforestation methods have evolved in a rather predictable reflection of established agricultural techniques. Scarification and other methods of site preparation have their agrarian counterpart in plowing. The clear-cut is mimicked by the combine, slash burns by field burning, and timber stand improvement by weeding. Both agriculture and forestry use extensive genetic engineering, narrowing the gene pool in an effort to produce a "better" fir tree or tomato plant. Certainly in this vein is the reliance of many foresters on a range of herbicides, similar in formula and effect to those used by commercial agriculture.

Agricultural use of herbicides is, on the whole, an accepted practice in much of the world. Widespread criticism rarely arises, and is usually a short-lived reaction a well publicized event, such as the Alar apple scare (Time 1989) or a spectacular train derailment into the Sacramento River (Elmer-Dewitt 1991; Chemical and Engineering News 1991).

However, the use of herbicides in forestry has often met with vociferous opposition and criticism, and since the early 1970s, the front lines of this battle have been in the Oregon Coast Range. There are several reasons why the this region has been a crucible for this issue.

Oregon has long been the largest timber producing state in the nation, and 78% of the state’s harvest comes from Western Oregon (Basset and Choat 1973). The one square mile checkerboard ownership pattern of Bureau of Land Management (BLM) and private lands, a relic from the O & C Railroad land giveaway of a century ago, intersperses rural, private
properties with federal and industrial forest lands. Thus, there is far more private land in the Coast Range than in the Oregon Cascades, which allows a higher human population in timbered areas. Many of the current residents came within the last few decades, many of them with a back-to-the-land ethic and more pro-environmental leanings than more established locals. Rural residents generally live where they do because they do not have to expose themselves to environmental toxins, noise and other hazards of urban life, and the "don't tread on me" attitude still reigns regarding privacy and property rights. The higher percentage of the land in private ownership means more is under the control of corporate timber owners, who generally manage their lands more intensively than federal agencies. This blend of land ownership between independent-minded locals and corporate forestry has exacerbated the issue.

The ownership patterns of forest land in much of the Coast Range look more like El Salvador than the United States, with a small cadre of industrial owners controlling a vast majority of the resource base. This is seen in Figure 1. This GIS map was created from a property ownership coverage compiled at the Forest Science Laboratory at Oregon State University. The GIS coverage, and several others used in this study, was acquired through Pacific GIS, a non-profit “public access” GIS consulting firm based in Portland, Oregon.

The intransigence seen in most current debates over forest practices is heightened in the question of forest herbicides, which at times seem more grounded in religious fervor than scientific evidence. On one side, a Coast Range resident is convinced that a Vietnam-like helicopter hovering sixty feet away from her home (the legal minimum buffer), spray booms
open, a mist of dioxin contaminated 2,4,5-T herbicide settling onto her vegetable garden, children and well, is a significant health risk. She may be even more convinced if she sees hundreds of dead crayfish in a sprayed creek, her children are all sick at once with the same unusual symptoms, and several neighbors have spontaneous abortions within several months of the spraying. On the other side is the Monsanto chemist who drinks 2-4-D on live television to prove its safety, and occupational safety specialists who cite statistics that manual brush removal with power tools poses a greater health risk than herbicide application. (Has, the industry pundits say, a cast-in-stone, cause and effect relationship ever truly been established between cigarette smoking and lung cancer?) The truth, as in all polarized debates, lies somewhere in between.

In recent years, sentiment and science have merged in questioning forestry herbicide use. The rise of disciplines as landscape ecology and conservation biology have given a measure of academic credence to the concept of cumulative effects, whereby incremental impacts over a landscape scale may affect biotic/physiographic processes in wildly unpredictable ways (Geppert et al. 1984). These studies have helped turn the spotlight on all aspects of modern industrial forest practices and their role in ecosystem change, and herbicide use is certainly among the activities being questioned.

* * * * * * * *
With the long-standing interest in this issue, it seems that accurate analysis and mapping of the spatial extent of forest herbicide spraying would have been done long ago. To some degree, it has. Larger private landowners may keep their own accurate records and maps of operations, but they are usually interested only in their holdings. Various citizen groups have created mylar overlay maps showing locations of herbicide spraying, but these efforts have not shown an accurate acreage value of herbicide use at a specific location over a multi-year period.

A definite hindrance in creating herbicide use maps (or for that matter, any forest activities map) is simply a lack of readily available data from which to make one. The spatial patterns of other forest practices and/or impacts (e.g., road networks, clearcuts, windthrow or mass wasting), are relatively easy to determine through established geographic techniques such as air photo and remote sensing image interpretation. However, these techniques cannot be applied to analyze herbicide use, as there is no definitive visual record of herbicide application. Thus, any study of herbicide records must rely on written records. Only in the last few years have both data and microcomputer availability been sufficient to attempt such mapping and analysis.

**Objectives of this study**

There are three primary objectives of this study: one general, one specific, and one methodological: 1) paint a picture of the “who, when and how much” of herbicide use in
Lincoln and Benton County from 1991 to 1994; 2) determine if all large forest landowners use herbicides on their lands at the same rate; and 3) detail the methods used so others may perform a similar analysis. To achieve these objectives, charts and maps showing various relationships between season, year, acres owned per landowner, acres sprayed per landowner, and total acres sprayed per county are presented.

* * * * *

I am not a biochemist, a rural landowner, a toxicologist, nor a forester. What I am is a geographer. It is my belief that geographers have two important contributions to make in forest policy debates. One is an understanding of the uses and limitations of scale in examining a landscape, and the second is having the technical toolbox and graphical abilities to clearly express complex scale-data relationships in the form of maps. The root of our most pressing environmental problems lies in the human inability or unwillingness to perceive the impacts we effect beyond a certain spatial and temporal scale. Solutions to pressing environmental problems must begin simply with some idea of the scope of the issue. Environmental degradation that cannot be perceived, or is perceived in a limited manner, clearly cannot hope to be adequately resolved. A map, which can render landscape level changes over time, can be a tool used to gain a new appreciation and insight into our relation to the environment.
We are a society awash in data and information, and woefully short on wisdom. The stepping stone between these is knowledge. Through their understanding of scale and ability to express this understanding through maps, geographers have a critical role in furthering this procession toward knowledge and eventual wisdom we so clearly need. It is in this spirit in which I undertook this work. May further understanding, a passing of knowledge, informed discussion, and a glimmer of wisdom be its result.

* First inspired by Jerry Franklin, during his introductory comments before a poetry/book reading by the poets/authors Richard Nelson and Gary Snyder, San Francisco, September 1991.
Private Industrial Forest Lands, Oregon Coast Range

(black areas represent private industrial lands)
Background

Definition of Phenoxy Herbicides

Pesticides are chemicals used to kill or control "pests". Herbicides are a class of pesticides used for killing/control of plant "pests", be they dandelions or 20 foot alder trees. Most herbicides used in forestry are in the class of compounds called phenoxy herbicides, whose name comes from the synthesis of chlorine and phenol. For decades, the most commonly used herbicides on forest lands were the compounds 2,4,5-T (2,4,5 trichlorophenoxy acetic acid) and 2,4-D (2-4 dichlorophenoxy acetic acid), a similar phenoxy herbicide just one chlorine atom different that 2,4,5-T. These two compounds were used on approximately 75% of all forest lands treated with herbicides (Gratkowski 1975). An experienced herbicide researcher stated that, for forestry use, "[no] chemical is as versatile or effective as 2,4-D or 2,4,5-T" (Gratkowski 1978). A highly toxic form of dioxin, TCDD (or 2,3,7,8 tetrachlorodienzo-p-dioxin) is a contaminant in 2,4,5-T, formed during its manufacture. In 1979, approximately 95,000 acres of Oregon timber lands were sprayed with 2,4,5-T (Green 1982).

For a forester, the value of the phenoxyes lies in their selectivity; i.e., killing the weeds and not the crop. This is done by altering the herbicide application rate, carrier, concentration, and season (Gratkowski 1978). Absorbed through the foliage and passed to the entire plant, phenoxy herbicides ironically kill plants by encouraging growth. By
mimicking a naturally occurring growth hormone, the herbicides cause cell mutation and abnormal-excessive tissue growth (Green 1982), leading to death.

**Herbicides and Forest Management**

Following a wildfire, landslide, clearcut or similar disturbance in the Coast Range, pioneer species such as red alder (*Alnus rubra*), vine maple (*Acer circinatum*), and salmonberry (*Rubus spectabilis*) are some of the first plants to establish themselves on the newly disturbed soil and in the abundant sunlight. These species provide leaf litter, shade, soil moisture retention, and, in the case of red alder, fixation of atmospheric nitrogen, creating conditions for the succession of conifer species which will eventually claim the site (Raphael 1981; Tarrant 1961).

However, the industrial silviculturist does not see alder and salmonberry as necessary successional stages, but as competitors, robbing the commercially desirable conifers of moisture and nutrients. The short harvest rotation preferred by most foresters in the Pacific Northwest attempts to speed the succession from seeding to marketable tree as much as possible. One of the ways this is accomplished is through "vegetation management", which is essentially killing or suppressing competing, non-commercial (i.e., "weed") species through a variety of means (USDA Forest Service 1976).

The definition of a weed species is flexible. Resource geographers have long noted that "resources" per se have no intrinsic quality which makes them valuable; they are only valued through an admittedly anthropocentric human choice and desires (Zimmermann 1951).
This line of thinking may be easily reversed, in examining the notion that "weeds are not, they become". It is noteworthy that red alder, long considered one of the most troublesome "weed" species, is now a commercially desirable tree in many areas of the Northwest (McGillivray 1981). After decades of alder control with herbicides, their growth is now actively encouraged in many areas.

Forest herbicide use is justified on the assumption that increased conifer yield comes from killing/control of weed species, and that herbicide use is cheaper and more effective than other manual means of vegetation management. Aerial spraying is the most common means of application. Herbicides are commonly used in five types of forest management activities: release, site preparation, rehabilitation, timber stand improvement, and "maintenance of improvements"; i.e., roadside spraying (Green 1982; USDA Forest Service 1976). Many thousands of miles of logging roadsides are sprayed each year, while not technically a forest management activity, herbicide concentrations in roadside spray operations are often as much as twelve times higher than in aerial application (Van Strum 1983) and thus may have significant environmental effects.

The data used for this study do not always indicate if a spray operation was specifically for road maintenance, and thus an analysis of only roadside herbicide use was not possible.

Of the uses mentioned above, release and site preparation are the most common (Gratkowski 1975). In release, the goal is not necessarily to kill weed plants entirely, just to suppress them so light, water and nutrients can reach the commercially desirable tree. A
release spray often occurs in the third to fifth year after planting (Gratkowski 1975), and is
often done aerially. Naturally, such an operation must use a selective herbicide, one that will
inflict maximum damage to the target tree while minimally harming the commercial tree.
Phenoxy herbicides are generally more effective on broadleaf deciduous species. When used
at the proper time of year, generally late spring or summer, the phenological differences
between conifers and the normally targeted weed species usually allows successful
application, with dormant conifers being especially resistant (Radosevich et al. 1980).

Site preparation, on the other hand, usually does not require such selectivity. With no
commercial trees on site, herbicides are applied to kill a much higher percentage of the
existing vegetation with a minimum of resprouting. This allows the use of a broad spectrum
herbicide, commonly in a higher concentration or higher application rate than would be used
in a release spray (Gratkowski 1975).

**History and Development of Phenoxy Herbicides**

As the Romans poured salt on the fields of their enemies to destroy their crops, the
20th century development of phenoxy herbicides was closely tied to military applications. In
the closing years of World War II, the U.S. army tried to develop herbicides to defoliate
Japanese island strongholds in the Pacific. The war ended before these compounds could be
perfected, but the possible civilian uses for right-of-way clearings, agriculture and forestry
was clear. As early as 1947, these phenoxy herbicides were being used for forestry
applications (Egler 1947). In 1948,
the first field tests in Oregon were conducted near the Five Rivers area on the Siuslaw National Forest, conducted by the U.S. Forest Service and Oregon State College (Hawkes 1953; Van Strum 1983). This Five Rivers area is within the study site of Lincoln and Benton County; see Figure 2.

Two significant events in herbicide history occurred in 1962: the publication of Rachel Carson's *Silent Spring*, and the first spray missions of Agent Orange, the most widely used defoliant in Vietnam. Carson’s book brought the hazards of herbicide use to the awareness of mainstream America, and her eloquent writing certainly influenced the herbicide legal battles which followed in the wake of its publication. Agent Orange is a 50-50 mixture of 2,4,5-T and 2,4-D, and earned its name from the orange color-coded barrels in which it was shipped. Formulations used in Vietnam had especially high levels of dioxin (Green 1982).

Mounting evidence of human health and environmental impacts led to Senate hearings ending the military use of Agent Orange in late 1970. Important evidence in this decision was the high number of miscarriages experienced by South Vietnamese women exposed to the toxic herbicide (Feinslifer 1984). However, as military uses were drawing to a close, forestry applications of similar compounds were just beginning.

**Emergence of Controversy**

As herbicide sprays containing 2,4,5-T, 2,4-D and other phenoxy compounds were used increasingly throughout the 1970's in the Oregon Coast Range, more and more residents began to question the safety of their use. Fledgling activists took a more formal turn in 1978,
when a group of women living in the hills around Alsea, Oregon (see Figure 2) wrote to the Environmental Protection Agency (EPA) describing what they felt to be an unusually high incidence of spontaneous abortions and various other birth complications. Aerial spraying of 2,4,5-T on both private and federal lands had been a common practice in this region, much of it close to the Five Rivers area where some of the first forestry herbicide experimentation took place.

These letters spawned the EPA's Alsea II study (Ruff 1978), the most "rigorous" study to date of the health effects of forestry herbicide use. These studies found significant differences in rates of miscarriage between treatment (sprayed) and control sites, and a high correlation between the timing of spraying and the occurrence of abortions. (EPA 1979; Johnston 1979; Green 1982). Subsequently, it was disclosed that samples of miscarriage tissue and sludge and sediment from water supplies in the Five Rivers/Alsea area had TCCD levels from 160 to 5800 parts per trillion (ppt). 5800 ppt is approximately six times the level used by the Center for Disease Control as a benchmark for evacuating residents of Times Beach, Missouri, another area contaminated with TCCD (Hayes 1983).

The results of the Alsea study were attacked, with both proponents and opponents of the spraying claiming the study was poorly designed and lacked scientific rigor (Ruff 1979). Both were essentially correct, as determining a definite causal relation between long-term, incremental herbicide exposure and human health impacts from a field study is next to impossible (Van Strum 1983).
While the scientific quality of the Alsea II study was questionable, it initiated an interesting chain of events. This study, combined with the 1970 ban on military use of Agent Orange, the spectacular toxicity of dioxin, and a growing mound of studies on the health effects of 2,4,5-T, prompted the EPA in 1979 to issue an emergency suspension of all forestry uses of 2,4,5-T on public and private land. This was the first emergency suspension ever ordered by the EPA (Kadera 1979).

The suspension of 2,4,5-T did not halt forest herbicide use, but led to a change in compounds. Media and scientific attention to the dioxin present in 2,4,5-T overshadowed possible harmful effects of a host of other chemicals regularly used on forested areas. In 1983, a lawsuit (NCAP v. Block) was filed by citizen groups, contending that the Forest Service and BLM had not prepared an adequate Environmental Impact Statement (EIS) regarding the effects of herbicide use on their lands. This suit was upheld, and the settlement in March 1984 enjoined all herbicide programs on Federal forest lands (including Bureau of Land Management holdings) in Oregon and Washington (Grier and Foote 1992). Shortly after, the Forest Service voluntarily halted all aerial spraying nationwide. The evolving political sophistication of Coast Range activists had evolved from personal outrage to community activism, which in turn led to litigation and publicity which eventually set national environmental policy.

The ban on federal lands spraying was lifted in June 1990 opening the door for further spraying on federal land. Public scrutiny will probably limit spray activities on federal lands in
the near future; however, the BLM announced in 1992 that it plans to resume limited use of 2,4-D on its lands (Associated Press 1992).

Herbicide use is not a requirement in modern forestry. It is a management decision; a decision in the vein of clearcutting and other area-wide forest practices which ignore the idiosyncrasies of ecologically defined forest parcels in favor of proximity to roads, helicopter landing zones and survey stakes. Options to aerial spraying exist. Despite dire predictions of increased costs and unemployment after the 2,4,5-T ban of 1979 (Green 1982), some foresters appeared to be pleasantly surprised:

The loss of herbicides on the Siuslaw National Forest has been less traumatic than anyone on the Forest would have expected. The loss required us to look at new alternatives in vegetation management that would otherwise have taken years to develop or never developed at all. Unless management activities change dramatically, we are confident that we can continue to manage the Siuslaw National Forest as good land stewards without the use of herbicides (Turpin 1988).

This previous discussion focused on the political battles regarding herbicide spraying on federal lands in the Oregon Coast Range, largely in the Siuslaw National Forest. During this time, herbicide spraying on private lands was of equal concern. However, it could not be legally challenged as could be the federal spray program. Federal agencies must abide by the regulations of the National Environmental Policy Act (NEPA), which requires an EIS for federal forest activities. These agencies, managing resources owned by all U.S. citizens, are increasingly sensitive to political and citizen pressure about forest management practices. Citizens successfully used these leverage points to hammer out dramatic changes in national US Forest Service policy.
However, in most of the Coast Range, federally owned land comprises a small percentage of the total land area (see Figure 1). Private landowners are not under the provisions of NEPA, are generally not as easily swayed by shifting political winds, and have no multiple use, sustained yield mandate as does the U.S. Forest Service. During the battles over herbicide use on federal lands, private timber owners continued to spray. They continue to this day. In 1992, private forest landowners in Oregon notified the state that approximately 300,000 acres were to be treated with herbicides, double the acreage of a decade earlier (Cox 1994). The herbicide spotlight has turned to these private lands, and is the focus of this study.
Methods

Study Area

The study area selected for this analysis consists of Lincoln and Benton County, Oregon, both in the central Coast range. These counties were selected for the following reasons: 1) the area was the focus of the earlier Alsea II study, and no subsequent analysis of herbicide use had been performed since that time; 2) the adjacency of two counties with different land uses and ownership characteristics might highlight different patterns of herbicide use; and 3) the close proximity of the study areas to Oregon State University and a personal familiarity with the area. Each county was mapped at the square mile (section) resolution.

There are differences in size, land use and ownership patterns between the two counties. Lincoln County is approximately 1/3 larger than Benton; Lincoln County has a total area of 998 square miles (2,584 km²), compared with Benton County at 668 square miles (1,730 km²). Federal lands (US Forest Service and BLM) account for 30% of the area of Lincoln County and 17% of Benton County. Privately owned timber lands comprise a large area of each county, but substantially more in Lincoln County. Lincoln County has a total of 334,900 acres of private timber land out of a total area of 630,400 acres (53%), whereas Benton County has a total of 154,834 acres of private timber of a total area of 427,520 acres (39%). Lincoln County has relatively little cropland or pasture lands, with just 5% of private land in these categories. Benton County has 26% of its lands in private pasture
or cropland (Loy et al. 1976, Real Property tax assessor records, Lincoln and Benton County). Thus, Lincoln County has more public and privately owned forest land than Benton County.

Within each county, one smaller study site was chosen to map herbicide spray at a higher spatial resolution (a 40 acre 1/4 1/4 section). In Benton County, the MacDonald Forest area was selected because of its high recreation use, proximity to Corvallis, and its management by OSU. In Lincoln County, the Beaver Creek watershed was chosen as a detailed study site because this area has been a center of herbicide use controversy in recent years (Finley 1992). See Figure 2.
Data Sources

The requisite data for a study on forestry herbicide use have only recently become available. The Oregon Forest Practices Act (OAR-629-24) passed in 1971 by the State Legislature, set minimum guidelines for all major forestry activities. The statutes of the Act are administered by the Oregon Department of Forestry (ODF), and all forestry activities on private and state owned lands are under the ODF's jurisdiction. Regulation of this act requires private landowners to notify ODF for five general types of activities: tree cutting or harvesting, road construction, slash disposal, site preparation, and herbicide application (ODF, Rules and Statutes, undated booklet). If landowners wish to perform certain regulated activities on her/his land, s/he must file a "Notification of Operation / Application for Permit" with ODF at least 15 days prior to the proposed activity. Notifications are routed through the ODF district office which is closest to the proposed forestry operation, so that the district office processes and maintains all notification data for its particular jurisdiction. For ODF, the permitting process serves two primary functions: 1) to help state foresters prioritize their on-site inspections; and 2) to assist the Oregon Department of Revenue (ODR) in collecting taxes on timber sale revenue (ODF, FACTS brochure, undated). These notification records are publicly available, and are the basis for this study. (More details on data acquisition are given below.)

The person filling out the notification form supplies all information, including an estimate of acreage, board feet and/or linear feet, and the township / range / section 1/4 1/4
section location of the operation. An air photo or map showing the area(s) of the operation must also be attached. The main reason for the air photo or map is to allow state foresters to make a quick assessment of the accuracy of the acreage/board feet/linear feet information supplied by the applicant. If a major discrepancy is noted by the forester, the landowner is notified and the acreage value changed on the permit.

Regarding herbicide spraying, the Forest Practices Act also requires herbicide spray operators to maintain daily records of spray operations. These records must include hourly records of temperature, wind speed and wind direction, and the name, mixture and application rate of the herbicide used. These records must be maintained by the spray operator for a period of three years after the operation, and must be made available to a State Forester under special circumstances (ODF, Oregon Forest Rules and Statutes). These records are not public information, and they are rarely checked by a State Forester. Clearly, these records would be of value if one's interests lay in biological effects of herbicides at site specific locations.

The permit notifications maintained by ODF are (nearly) freely available as public information. The Oregon Public Records Act of 1973 mandates that almost all information gathered by state or local agencies be made available to all citizens. (There are some exemptions to this Act, generally regarding issues of privacy). Permit notification data are available from January 1990 to the present. Prior to 1990, the data were stored on a large mainframe computer. After 1990, ODF switched to a microcomputer platform and
commercial database software. Due to the different file formats and other difficulties involved in downloading and data transfer, notification information from before 1990 is difficult to access. Custom data queries may be arranged through ODF, but pre-1990 data were not used for this analysis.

To more readily disseminate these data to interested parties, ODF implemented a system it calls FACTS (Forestry Activities Computerized Tracking System). Permit notification data are packaged by yearly quarter (e.g., January 1 to March 31, 1994) and by ODF district office, and cost $8.00 per quarter. Data are mailed on a floppy disk in Dbase or Paradox format.

In cases where an ODF district encompasses an entire county (e.g., Tillamook), data acquisition and analysis is fairly straightforward. For example, to analyze forest activities in Tillamook County for a period from January 1990 through December 1994 would require 20 disks, @ $8.00 each, for a total cost of $160.00. However, as ODF district boundaries do not always follow county lines, some counties may require data from more than one district. For example, Lincoln County is under the jurisdiction of both the Toledo and the Philomath district; thus all currently available (Jan. 1990 - Dec. 1994) data for this county would require 40 disks at a cost of $320.00. One can also "subscribe" to receive the FACTS data in diskette form, whereby permit notification data for requested districts mailed as it becomes available after each yearly quarter. Capability to download the FACTS data via the Internet will hopefully arrive soon.
To analyze herbicide spraying in Lincoln and Benton counties, all available data were purchased from the following ODF district offices: Toledo (Lincoln and Benton) Philomath (Lincoln and Benton) and Dallas (Polk, Yamhill, and Benton). Data were purchased from January 1990 to December 1994, but only permit notification data from the period January 1991 to December 1994 were used in the analysis. Certain districts had complete records for the entire four year period. Others had significant gaps in the 1990 data which would have significantly affected the analysis (e.g., a complete absence of herbicide spray records for the first three months of 1990 in the Toledo district). Due to this variation in data quality among different districts, data from 1990 were omitted from this study.

It is important to note some inherent shortcomings in the data set. As the operators or landowners themselves fill out the notification forms, occasionally they fail to fill out the entire form. For example, an acreage value, landowner, or township / range / section coordinate might be missing, and thus obviously cannot be counted in the analysis. In spite of these limitations, the data are the best available and are of sufficient completeness for a landscape-level study such as this. (For related comments, see ‘Limitations of this study’)

Data Structure

Each ODF FACTS data diskette contains three files which are relevant to spatial analysis of forest activities. These files are called table1.dbf, table2.dbf and table3.dbf, and roughly correspond, respectively, to the "who", the "what", and the "where" of forest activities. Cumulatively, these files commonly have a total of approximately 90 fields, or
columns. Many of these fields contain information irrelevant to the mapping and data analysis of this project (e.g., the complete address of the landowner and date the notification was processed by ODF), and were deleted from the database during the initial “cleaning” in MS Excel (see Appendix A, Part I). After deleting the unneeded fields, the remaining data could be more easily processed. (See Table 1.)
Table 1: Relevant fields in each data file after initial "cleaning".

Analytical Approach

A significant portion of this study involved: 1) determining the meaning of the occasionally cryptic field codes; 2) deleting unnecessary fields; 3) deciding how to join the files so data were not mistakenly deleted or repeated; and 4) calculating correct acreage values for each section. The division of the data into three separate files further complicated the analysis. The relation of these three tables is somewhat confusing, but understanding it is obviously crucial to the accuracy of the final analysis. Thus, a detailed explanation is provided.

Various software combinations were tried in an attempt to develop a simple, efficient and accurate method for calculating acreage values and mapping the data. First, a
combination of Arc-Info Tables macros and Excel spreadsheet manipulations were used to
calculate acreage values. However, the recent release of an improved version of the database
program Access allows a much simplified means to calculate the acres needed for mapping
and graphs. This is the methodology detailed in Appendix A.

To simply determine the landowner (from table1.dbf) and the acres s/he sprayed
(from table2.dbf), a straightforward join between the two tables would be sufficient.
However, determining an acreage value for the total acreage sprayed per section (from
table3.dbf) required rather extensive spreadsheet calculations. For those with a specific
interest in this methodology, to work through Appendix A, and/or to help interpret Figures 3-
ab, there are a few important points to keep in mind:

- As can be seen in Table 1, the field notification number appears in all three files.
- A given notification number may be divided into more than one unit, and one unit may be
divided into more than detail.
- A notification number is divided into unit(s) if there are at least two different acreages
associated with it, i.e., two separate spray operations on the same notification number.
- An acreage value is associated with a particular unit, and this acreage may be divided into
different township/range/section 1/4 1/4 sections. (One section = one square mile, or 640
acres; one quarter section = 160 acres; one 1/4 1/4 section = 40 acres.)
- A new detail is added with every new section which is affected.

Essentially, progressing from table1.dbf to table2.dbf moves to greater data detail
and smaller units of measurement. The challenge is to generate final numbers while
maintaining this relationship and accuracy. See Figure 3a and Figure 3b for two typical data
records, the relation between the three tables after the files have been joined, and a sample
map which represents the area affected by the operation.
Scenario 1 (simple): A notification number (157) is assigned to a 35 acre spray operation, to take place in a single section (section 16). As there is only one section, there is a single detail, which spans four 1/4 1/4 sections. A portion of the database showing these records might look like:

<table>
<thead>
<tr>
<th>NOTIFNUMBER</th>
<th>UNIT</th>
<th>ACRES</th>
<th>DETAIL</th>
<th>TOWNSHIP</th>
<th>RANGE</th>
<th>SECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>157</td>
<td>1</td>
<td>35</td>
<td>1</td>
<td>05N</td>
<td>04W</td>
<td>16</td>
</tr>
</tbody>
</table>

Figure 3a: Sample database entry and map supplied with notification forms
Scenario 2 (more complex): A notification number (218) is issued to spray two units; unit 1 for 80 acres and unit 2 for 75 acres. As the units span three and two sections respectively, there are a total of five details. A portion of the database showing these records might look like:

<table>
<thead>
<tr>
<th>NOTIFNUMBER</th>
<th>UNIT</th>
<th>ACRES</th>
<th>DETAIL</th>
<th>TOWNSHIP</th>
<th>RANGE</th>
<th>SECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>218</td>
<td>1</td>
<td>80</td>
<td>1</td>
<td>05N</td>
<td>03W</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td></td>
<td></td>
<td>05N</td>
<td>03W</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td></td>
<td></td>
<td>05N</td>
<td>03W</td>
<td>12</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>75</td>
<td>2</td>
<td>03N</td>
<td>02W</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td></td>
<td>1</td>
<td>03N</td>
<td>02W</td>
<td>7</td>
</tr>
</tbody>
</table>

Figure 3b: Sample database entry and maps supplied with notification forms
As all the FACTS data files all had interconnected data needed for the final analysis and mapping, the files had to be merged. This was accomplished for a four year period of data files for the Toledo, Philomath and Dallas ODF offices, which have jurisdiction over Benton and Lincoln County. This process, using the database program Access, is described in Appendix A. After merging the files, two queries were run: one for Lincoln County with herbicide spraying as the primary activity, and one for Benton County with herbicide spraying as the primary activity. The resulting data file was exported to the spreadsheet program Excel for subsequent calculations. The detailed steps of this analysis may be seen in Appendix A.

The file resulting from these spreadsheet permutations contains records spanning four years in a single county. The records in the file show herbicide spray down to the 1/4 section resolution, and a subtotal of the total acres sprayed per section over four years. The tables and charts in figures 5-11 were created from these multi-year summaries. The landowner and total acres owned were taken from the real property records from the Benton and Lincoln County tax assessor office.

**GIS Coverages**

Arc-Info coverages of Lincoln and Benton counties of United States Public Lands Survey (USPLS) sections were required. These were provided by Pacific GIS, a GIS consulting firm. They received the coverages from the Oregon State Service Center for GIS, and the coverages were then sent as zipped Arc export (.E00) files.
In addition to the county boundary and section lines, these coverages had remnants of the old Donation Land Claims (DLC). These are a surveyed system of property lines originating from the Donation Act of 1850, which predated the USPLS survey in many parts of Oregon. While of historical interest, these DLC lines do not correspond to the USPLS sections in use today. In the fertile agricultural area of the Willamette Valley, there were many of these DLC lines on the coverage; so many that it was more time efficient to digitize Benton County and the USPLS lines from scratch rather delete the DLC lines and add the proper USPLS arcs. In the more forested and hilly Lincoln County, there were fewer early settlers, and thus relatively fewer DLC lines. Here, it was more efficient to delete the DLC lines from the coverage in the Arc-Info module Arcedit, along with minor digitizing errors. The coverage was then cleaned and rebuilt to reestablish proper polygon topology.

**Merging acreage values with Arc-Info coverages**

The final step in data manipulation before map production was to match the total acreage sprayed per section value from the spreadsheet file with the appropriate section in the Arc-Info coverage of the county. One of these coverages (Lincoln) had township / range / section legal descriptions in the Polygon Attribute Table (PAT). Benton County, digitized from scratch, had no attributes. Thus, two different methods were used to perform this final acreage - location match.

For Lincoln County, the obvious solution was to join these two data files with a single item common to both files. This did not exist. This was solved by copying the PAT file from
the Lincoln County coverage into Excel. In Excel, the three items township, range and section were concatenated into a new item, trscode, which created a common item in both the spreadsheet and the PAT. The PAT was then saved in Dbase (.DBF) format and copied back into the LINC10 coverage directory. The Excel spreadsheet file was then saved in .DBF format, copied to the LINC10 directory, and the two data files joined on the common item, trscode. Now, a map could be created showing an acreage value associated with each section polygon. While Arc-View was used to create the maps in this paper, larger plotted maps were created from the Arcplot module of Arc-Info. The macro used for these Arcplot map composition may be seen in Appendix B.

Performing a similar operation for Benton County required a different approach. The Arc command createlabels was used to add label points in every section polygon, and then these label points were plotted. A field was added to the spreadsheet, id_number, to match the user_id field in the PAT for Benton County. Then, using the plot of the polygon label points, the USPLS coordinates of the first record in the spreadsheet file was noted, and the corresponding label point in the county plot was added to the record in the spreadsheet file. This created a common item in the two files, the label point, on which the files could be joined. This was repeated for all records, a moderately tedious process. The final step was the same as Lincoln County; the spreadsheet file was saved in a .DBF format, copied into the BENTON10 directory, and the two tables were joined on the common item benton10_id. The acreage values for the 1/4 1/4 sections in the detailed study sites in MacDonald Forest
and the Beaver Creek watershed were joined in the same manner. At this point, map creation and the creation of figures showing data relationships could begin.
Results

The data in the final spreadsheet file with totals from 1991-1994 can be presented in many ways to show relationships between landowners and acreage values. When examining these graphs, note that Lincoln County's land base is approximately 53% private timber while Benton County is approximately 39% private timber (Loy et al. 1976, Real Property tax assessor records, Lincoln and Benton County). Note that figures 5-7 and figures 10-12 use cumulative acreage values calculated for the four year period of the study, not year-by-year values.

To get a better idea of herbicide use patterns, we may start by examining the timing of the spraying, both in annual and seasonal acreages. These graphs may be seen in Figures 4 and 5. In the annual spray graph, Benton County shows a fairly steady rate of spraying from 1991 to 1993, with a mean acreage value of around 8,000. This value leaps to nearly 17,000 acres in 1994. Herbicide use in Lincoln County shows a greater annual fluctuation, with a peak in 1992 and a high point in 1994. The peak of both counties in 1994 is interesting; the total for Benton is almost equal to Lincoln, despite Benton's smaller percentage of private forest land. Looking at the seasonal variation in Figure 5, the spraying peaks in the summer months, but is also surprisingly heavy in the winter. In winter, the spray peak for Benton County almost equals that of Lincoln. There is very little spraying in the fall in either county.

Figures 6 and 7 show the top ten herbicide users in each county, and the total acres each landowner sprayed during the study period. Both counties show a pattern of a skew
towards one significant owner, then two to four medium spray acreages, and then four smaller owners filling out the top ten. There is a greater range of acreage values (from 670 to 17,659 acres) in Lincoln County than in Benton (from 1,057 to 9,458 acres).

In Figures 8 and 9, the ten largest private forest landowners in each county are graphed. The acreage owned is clearly skewed here as well, with the single largest landowner controlling more than twice as much as the next nearest landowner. The skewed pattern is especially apparent in Lincoln County. Here, the top three landowners control more than 220,000 acres of timber, or 66% of all private timber land in the county. Note that Lincoln County has six landowners holding 10,000 acres or more, while Benton County has just two landowners over 10,000 acres.

Figures 10 and 11 address the question of differing rates of herbicide use among landowners. This graph illustrates the total herbicide use by landowner, by county, as a percentage of the land owned by each landowner. The graphs were created by dividing the acres sprayed values (from Figure 6 and 7) by the total acres owned (from Figure 8 and 9) and expressing the resulting figure as a percent. Clearly, landowners spray at different rates. There is again a skew to the values, but this time there is greater variation in Benton rather than Lincoln County. The range in Benton County is even more striking, moving from 0% to 75% sprayed of land owned during the study period. The top percentage sprayed of land owned in Lincoln County is 44%. The low value in both counties is a fraction of one percent.

In Figure 12, we see shows six levels of herbicide spray and the number of square-mile sections in each category, by county. This is simply a graph of the values used to create
the actual maps of herbicide use, seen in Figure 13 and Figure 14. The number of sections sprayed in Lincoln County is significantly greater than Benton in the four lower categories, from 1% to 60%. In fifth class, Benton almost equals Lincoln, and then passes Lincoln in the "most intensive" class, more than 80%.

Finally, Figures 13 and 14 are the Arcview generated maps of herbicide spray at the section level in each county, created from the graphed values from Figure 12. Figures 15 and 16 show herbicide use at the 1/4 1/4 section (40 acre) resolution in the Beaver Creek watershed and MacDonald Forest, the detailed study areas.
Figure 4
Total acres of private forest land sprayed with herbicides in Lincoln and Benton County, 1-1991 to 12-1994. Data source: Oregon Dept. of Forestry FACTS data
Herbicide use by season

Figure 5
Total acres of private forest land sprayed with herbicides in Lincoln and Benton County, 1-1991 to 12-1994, by season. Data source: Oregon Dept. of Forestry FACTS data
Lincoln County: Acres sprayed per landowner

- Georgia-Pacific Corp.: 19,360
- Simpson Timber: 7,379
- Willamette Industries: 5,849
- Oregon Dept. of Forestry: 3,977
- Starker Forests: 3,108
- Boise Cascade Corp.: 3,080
- Diamond Timber Products: 1,712
- ANE Forests of Oregon: 1,216
- R D Gates Timber: 1,196
- Stimson Lumber: 741

ACRES SPRAYED

Figure 6
The "top ten" herbicide users on private forest land, Lincoln County, 1-1991 to 12-1994. Data source: Oregon Dept. of Forestry FACTS data
**Benton County: Acres sprayed per landowner**

![Bar chart showing acres sprayed for different landowners in Benton County.]

**ACRES SPRAYED**

*Figure 7*
Lincoln County: Ten largest private forest landowners

- Georgia Pacific: 14,960 acres
- Boise Cascade: 56,766 acres
- Simpson Timber Co.: 50,999 acres
- Willamette Industries: 14,207 acres
- Starker Forests: 12,170 acres
- Miami Corp.: 10,636 acres
- F. Vanek: 7,222 acres
- Diamond Timber Products: 7,066 acres
- Stimson Lumber Co.: 4,038 acres
- RD Gates Timber Co.: 2,831 acres

Figure 8
Ten largest private forest landowners, Lincoln County. Data source: Lincoln County real property records
Benton County: Ten largest private forest landowners

Figure 9
Ten largest private forest landowners, Benton County. Data source: Benton County real property records
Lincoln County: Percent sprayed of land owned

<table>
<thead>
<tr>
<th>LANDOWNER</th>
<th>Percent of Land Sprayed</th>
</tr>
</thead>
<tbody>
<tr>
<td>R D Gates Timber</td>
<td>42%</td>
</tr>
<tr>
<td>Willamette Industries</td>
<td>41%</td>
</tr>
<tr>
<td>Starker Forests</td>
<td>26%</td>
</tr>
<tr>
<td>Diamond Timber Products</td>
<td>24%</td>
</tr>
<tr>
<td>Stimson Lumber</td>
<td>18%</td>
</tr>
<tr>
<td>Georgia-Pacific Corp.</td>
<td>17%</td>
</tr>
<tr>
<td>Simpson Timber</td>
<td>14%</td>
</tr>
<tr>
<td>Miami Corp.</td>
<td>7%</td>
</tr>
<tr>
<td>Boise Cascade Corp.</td>
<td>5%</td>
</tr>
<tr>
<td>F. Vanek</td>
<td>0%</td>
</tr>
</tbody>
</table>

**Figure 10**
Figure 11
Percentage sprayed of land owned for the ten largest landowners, Benton County, 1-1991 to 12-1994. Data source: Benton County real property records and ODF FACTS data
Figure 12
Number of square mile sections receiving different intensities of herbicide spray, Lincoln and Benton County, 1-1991 to 12-1994. Data source: Oregon Dept. of Forestry FACTS data

Date Source: Oregon Department of Forestry FACTS data
One square represents one square mile

Fig. 13

Data source: Oregon Department of Forestry FACTS data.
One square represents one square mile.
Forestry Herbicide Use: Lincoln County, Oregon, Beaver Creek Watershed, 1991-1994

Date Source: Oregon Department of Forestry FACTS data
One square represents one 40 acre 1/4 1/4 section

Beaver3
- no spraying
- 1-8 acres; 1-20%
- 9-16 acres; 21-40%
- 17-24 acres; 41-60%
- 25-32 acres; 61-80%
- >32 acres; >80%

Fig. 15
Forestry Herbicide Use: Benton County, Oregon, MacDonald Forest, 1991-1994

Data Source: Oregon Department of Forestry FACTS data
One square represents one 40 acre 1/4 1/4 section

- no spraying
- 1-8 acres; 1-20%
- 9-16 acres; 21-40%
- 17-24 acres; 41-60%
- 25-32 acres; 61-80%
- >32 acres; >80%

Fig. 16
Discussion

Significance of Findings

The charts and maps created from this analysis show clear differences in herbicide use patterns in the study area. Lincoln County has a higher overall herbicide use, as seen in Figures 6, 7, and 11. This should be expected; as noted above, Lincoln County is both larger than Benton County and has a larger percentage of its land base as privately held timber. However, Benton County shows a few anomalies, particularly in the higher “percentage sprayed of land owned” values (Figure 11) and in the greater number of sections which were the most intensively sprayed (Figure 12). Let us again examine the charts, and discuss possible interpretations of the data.

In Figure 4, herbicide use by year, the peak in 1994 is the most distinctive feature. It would be interesting to compare the actual harvest acreage from a few years ago, e.g., 1991-1992, and see if the harvest was correspondingly high then as well. An increased harvest rate on private lands in the early 1990's corresponds with the federal timber sale injunctions due to the Northern Spotted Owl habitat protections, enacted in 1990. One might well expect a peak in herbicide spray to follow two to three years after a peak in harvest rate; this lag period may occur while the seedlings (and “weeds”) grow to compete with each other, and then the spray operations begin. Should this correlation be true, and harvest rates were also
high in 92-93 and 93-94, then we may predict the relatively higher herbicide use rates to continue in 1995 and 1996.

Figure 5, herbicide use by season, shows a peak in the summer months and a definite low in the fall. As mentioned in the background (section C, herbicides and forest management), the greatest selectivity in herbicide use is realized when there are significant phenological differences between the “crop” and the “weed” species. This may well happen in late summer, when the spring growth of the conifers has mostly ended but the deciduous trees are still in leaf.

Another interesting finding: during the Alsea II study, it was noted that most of the spraying happened in the spring months, with the miscarriages occurring a month or so following the spraying (EPA 1979). The summer peak noted here, 15 years later in the same study area, appears to be different.

Figures 6 and 7, acres sprayed per landowner, begins to tell the story of who the top herbicide users are. There was a total of 52,327 acres of herbicide use in Lincoln County during the study period. The top ten spraying landowners in Lincoln County sprayed a total of 43,945 acres. Thus, these “top ten” accounted for 84% of all herbicide use in Lincoln County from 1991-1994. In Benton County, there was a total of 38,300 acres sprayed during this period. The Benton “top ten” sprayed 31,753 acres, and were thus responsible for 83% of total herbicide use. The fact that Georgia-Pacific and Starker are the top herbicide users should be expected, as they are by far the largest landowners. Figures 6 and 7 become more meaningful when combined with the largest landowners, Figures 8 and 9.
Figures 8 and 9, acres owned per landowner, add more to our understanding as we see the spray acreages in proper relation to the acres owned. In Lincoln County, the ten largest landowners control 84% of the total private timber lands; in Benton County, the top ten control 63% of the private timber. What Figures 6 through 9 really address is the dominance of a few large private landowners in Lincoln and Benton counties. It should be noted that Oregon State University is not a private landowner, and their ownership records do not appear on the Real Property tax assessor records. Thus, university owned forest, while substantial, could not be graphed on this chart nor in Figure 11.

The real summary charts of this project are Figures 10 and 11, where we see the true relation between acres sprayed and land ownership. The values here were calculated by dividing the acres sprayed by the land owned, and expressing the resulting value as a percentage. For example, as Georgia-Pacific is by far the largest landowner in Lincoln County (from Figure 8), it is no surprise to find they are the landowner who has sprayed the most acres in the last four years (from Figure 6). However, when this spray acreage is divided into the land owned, we see that Georgia-Pacific is spraying a relatively small percentage (15%) of the land they own \( \left[ \frac{17,659}{114,960} \times 100 \right] \).

There are some interesting trends to note in Figures 10 and 11. There is clearly a wide range of herbicide use among the large landowners, ranging from essentially zero up to 75% of land owned. In general, there seems to be a slight inverse relationship between landowner size and the percentage of land sprayed, with this relationship slightly more apparent in Lincoln County than in Benton. For example, in Lincoln County the tenth ranked
landowner in size (R D Gates) had the highest spray percentage (44%). Georgia Pacific, the largest landowner and the biggest herbicide user, ranked fifth in spray percentage, spraying 15% of their lands. This relation of the largest landowners is mirrored in Benton County. Here, the largest landowner and herbicide user (Starker Forests) also ranks fifth, spraying 21% of their holdings. The seventh largest Benton County landowner, Agency Creek, ranks second in spray percentage, using herbicides on 63% of their lands during the study period. The data provide no apparent reason for this inverse relationship between landowner size and amount of herbicide use. As noted above, Benton County (Figure 11) shows a greater range of percentage values than Lincoln County. When viewed with the other charts in this section, this greater range of values indicates that Benton County generally has smaller landowners who spray their lands more intensively than in Lincoln County.

The final chart (Figure 12) is simply a graph of the values from which the county wide herbicide maps (Figures 13 and 14) were created. Lincoln County has a greater overall number of sections sprayed, especially in the smaller acreage values. However, this lead narrows and then is lost as the spray intensity levels increase to the “>80%” category. Of a total of 1090 sections or partial sections in Lincoln County, 489 (49%) had some level of herbicide use. Of 724 partial or complete sections in Benton County, 294 (41%) had some level of herbicide activity. This number indicates the sections with any spray activity at a given point(s) within the section, not that 49% of Lincoln County was sprayed with herbicides. Additional clarification on the proper interpretation of these values and the associated maps is given below.
Maps

The maps created from the spray acreages are shown in Figures 13-16. It is important to note that the legend and the corresponding color in a given section represents an average value of herbicide use within that square mile section (640 acres) over a four period. There are an infinite number of actual herbicide spray scenarios which could produce a the mean value. Consider the following two examples.

Within a single section (640 acres), there might be a one clearcut of 160 acres (1/4 section) with the remainder of the section untouched forest. Suppose the clearcut area had some stubborn brush that required herbicide treatments for three years in a row. In this case, the spray records would total 480 acres (160 x 3) for the section, and the entire section would be classified in the “385-512 acres; 61-80%” category, even though there was herbicide use only on 25% of the section. In another possibility, there might a clearcut covering 75% (480 acres) of the entire section, and there was a one time herbicide application on this whole area. In this case, the spray records would also total 480 acres (160 x 3) for the section, and the entire section would appear on the map in the “385-512 acres; 61-80%” category. This time, herbicide use was on 75% of the section rather than 25%; a more “realistic” representation. In both cases, herbicide use was not necessarily evenly distributed across the entire section, but averaged for the section. This mapping approach is appropriate for the landscape level view of a county. As seen below, the finer spatial
resolution of the 1/4 1/4 section mapping within the Beaver Creek watershed and MacDonald Forest offers a more precise view of the actual spray operations.

In Figure 13, the sprayed areas for Lincoln County are clearly clustered in the private forest lands. The large unsprayed sections in the north and south of the county generally correspond to the Siuslaw National Forest, where there has been no herbicide use during the study period. Spray patterns in Benton County, seen in Figure 14, show a similar pattern of use, but in the north and west. There is very little spraying in the flat, agricultural areas in eastern Benton County. The block of “>80%” acres sprayed in the north of the figure (Township 10 S, Range 5 W) is the area of Hoskins / Kings Valley, a region which has seen intensive private timber cutting in the last decade.

The final two maps show herbicide spraying at the 1/4 1/4 section resolution, the Beaver Creek watershed in Figure 15 and MacDonald Forest in Figure 16. Overall, Beaver Creek has experienced fairly little spraying, but areas which have been sprayed were sprayed fairly intensively. This intensive spraying occurred in the southeastern corner of the watershed, adjacent to Siuslaw National Forest land. In Figure 13, there are a total of 44 sprayed 1/4 1/4 sections. Of these, 36 had more than 60% of the area sprayed. Beaver Creek has not had widespread herbicide use, but where it has occurred, it has been fairly intensive.

The map of herbicide use in MacDonald Forest shows similar clusters of heavily sprayed 1/4 1/4 sections, and a majority of 1/4 1/4 sections which were not sprayed at all.
The more intensive spraying took place in the northeastern area, near Peavy Arboretum. There is a greater number of 1/4 1/4 sections in the lower spray intensity levels (less than 60%) in MacDonald Forest than in the Beaver Creek watershed.

**Summary of discussion**

From the data presented, the following generalizations may be made:

1. Overall, there is more herbicide use in Lincoln County than in Benton. This is expected, as Lincoln has a greater amount of private forest land than Benton.

2. There is an increasing trend in herbicide use in both counties from 1991 to 1994. If harvest levels also increased during this time, we may expect this trend to continue.

3. There is a peak in herbicide use in the summer (6-1 to 9-30).

4. There is one dominant landowner in each county (Lincoln, Georgia-Pacific; Benton, Starker).

5. The ten largest private landowners own 84% of the private timber lands in Lincoln County, and 63% in Benton.

6. The top ten highest spraying landowners in each county account for more than 80% of the total herbicide use.

7. The ten largest private landowners sprayed at very different rates, spraying from 0 to 75% of their land over the four year study period.
8. Herbicide use and land ownership have a slight inverse relationship. This seems more pronounced in Lincoln County. Benton County appears to have a smaller number of landowners who spray their lands more intensively.

Usefulness of method

The methods used in this study (detailed in Appendix A) may be readily used to analyze herbicide use or any other private lands forest practices throughout Oregon. Any type of forest activity may be queried from the FACTS data, not just herbicide spraying. The larger scale, 1/4 1/4 section resolution of the FACTS data may be especially useful. Site-specific spray patterns may become apparent at this finer resolution which may be masked or hidden if mapped at the square mile / section resolution. Familiarity with common database and spreadsheet programs is required, but advanced computer literacy is not needed. To analyze a large area or multiple years, data cost may currently be an obstacle. As computer networks become more widespread, this cost will hopefully become negligible.

Limitations of this study

This analysis attempts to provide the most objective and accurate portrayal of landscape level herbicide use possible with the given data. However, certain inconsistencies and errors in the data exist, and some aspects of the methodology which may limit the
usefulness of the study. The following concerns are listed in order in possible impact on the results.

*Variation in data completeness*

As noted above, data for the entire year of 1990 were not used in the analysis because of wholesale omissions of data. However, nearly every single data disk (yearly quarter) had occasional missing data. The most common problem were records spray operations which listed no acreage and/or no township / range / section location. (These records were often for roadside spray operations for which an accurate acreage value is difficult to determine.) These omissions are either due to the citizen omitting information on the notification form, or a data entry error at ODF. As may be seen in a careful reading of Appendix A, if a record was missing acres, it was impossible to map it and it was thus deleted from the data file. Records which lacked the landowner information (*lobusiness*) clearly could not be included in the landowner analyses (Figures x-x). Thus, the values presented here underestimate the spray acreage for which notification was actually given.

*Data were notification of intent, not actual accomplishments*

It is safe to assume that in most cases, a notification given for a certain acreage in a specific location means that the spray operation actually took place. However, there is no means to truly determine the exact location and acreage of spraying that happened after the notification was given. It is possible that notification was given, but the operation was not
actually carried out. As the data only show intention and not accomplishment, a definitive acreage value is impossible to determine.

Possible erroneous acreage values

As the acreage values in the data are approximations reported by the citizens who filled out the notification form themselves, it is almost certain that the true acreage sprayed is different than the data here indicate. Intentional under or overestimation of the acreage values would obviously cause a systematic error in the analysis. Due to the large total number of records analyzed over the four year period (Lincoln, 1,794; Benton, 1,258) it is assumed these estimation errors will average out.

Not mapping at the scale provided by the data

The data provided the potential to map an entire county at the 1/4 1/4 section resolution rather than to generalize at the section level. Due to hardware, coverage and time limitations, the county maps were made at the section resolution and the finer point locations available in the original data were generalized.

There were several reasons for this decision. One, at this writing, no coverage exists for these counties at the 1/4 1/4 section resolution. Two, such a coverage would have a vastly greater number of records, and be beyond the processing capabilities of a PC based GIS. (The section coverage for Lincoln County has a total of 1,090 complete or partial sections, i.e., 1,090 records. If each of these is divided into 16 1/4 1/4 sections, the resulting coverage would have a total of approximately 17,440 polygons; a very hefty PAT!). In addition, all 1/4 1/4 sections would have to be digitized section by section, a very tedious
process for an entire county. The more detailed analysis of the MacDonald Forest and Beaver creek watershed utilize the finer 40 acre spatial resolution of the data. In these smaller areas, digitizing the 1/4 1/4 sections was feasible.

If one really wanted to maintain the 40 acre resolution of the data over an entire county, this might be a situation when manually drawing in the 1/4 1/4 section on a mylar overlay of a base map, slow as it may be, might well be the most efficient means to produce a hard copy map. Of course, by following the processing steps detailed in Appendix A, accurate acre values could be noted in each 1/4 1/4 section; this would be a significant improvement over previous mapping efforts.

**Recommendations**

The results presented here and the methodology detailed in Appendix A will hopefully create an avenue for further studies of possible herbicide impacts, inspire additional data analysis of other forest activities in different or additional areas, and increase public awareness about these practices.

Soil scientists, fisheries biologists, and others interested in the possible environmental effects of forest herbicides may use these maps to find the most heavily sprayed watersheds, as a starting point for actual field measurements. The procedures for analyzing the FACTS data were created to analyzing herbicide use. But by simply querying a different activity code, a similar acreage, location and ownership analysis may easily be done for other forest activities such as road building or timber harvesting. These data are publicly available for all
of Oregon, not just the Coast range, and the steps in Appendix A will hopefully make it substantially easier for others to do similar work. While just two counties were compared here, looking at the entire Coast Range would be of even greater benefit. Analysis of the real property records for all Coast Range counties to determine the top landowners for the entire Range would be illuminating. Herbicides are usually used in close conjunction with clearcutting. One possibility might be to examine the data records for timber harvest for the areas which were most heavily sprayed, to see if there is a correlation. Examining demographic data and determining if the more heavily sprayed sections (e.g., greater than 61%) are in close proximity to inhabited areas would certainly be an interesting further step in this study. As mentioned above, using a GIS such as Arc-Info or Arc-View is not necessary to effectively map these data. For presentation purposes, a hand-drawn overlay sheet may well be more efficient and easier to produce than a computer generated product.

Finally, as emphasized in the introduction, the larger goal of this project is to provoke discussion and action on forest management practices in the Oregon Coast Range. Such discussion must begin with a factual understanding of the issues, areas, and landowners, and it is my hope that this project is a seed and catalyst for rational, constructive policy change.
References


Oregon Department of Forestry. FACTS brochure. Salem: OR: Oregon Department of Forestry.


Appendix A: Data Processing Methodology

General Information

The goal of processing these data is to create an Excel spreadsheet file with a multi-year summary of herbicide spray locations on Oregon forest lands. The relevant information on the processed data file will contain: the season and year of the spraying, the township, range, section, and 1/4 1/4 section legal description of all areas sprayed, the closest possible approximation of the total acres sprayed per section, and the land owner. This summary file may be used for other data queries, or to produce maps showing the spatial extent of herbicide spraying.

The step-by-step instructions which follow serve two purposes: 1) to specify the methodology which led to the final figures; and 2) provide a guideline for others to do similar analysis. Readers with more knowledge of database and spreadsheet programs will undoubtedly see easier and more efficient means to perform the same analysis. I only report the methodology developed through trial, error, and data loss paranoia, and with whose results I have confidence.

The following notation is used:

- The terms “row” and “record” are used interchangeably.
- The terms “column” and “field” are used interchangeably.
- Column/field headings (a.k.a. “headers”) are in bold italic font; e.g., notifnum.
- Commands and functions you specifically type or click are in bold font; e.g., =sum(G4:G144).
- Filenames and directories are in uppercase; e.g., 93WIN.

This documentation refers to “seasons” rather than the actual dates in which the data disks are organized. The seasons match the dates as follows:

- Winter: 1/1 to 3/31
- Spring: 4/1 to 6/30
- Summer: 7/1 to 9/30
- Fall: 10/1 to 12/31

Software used:

- Microsoft Access Version 2.0
- Microsoft Excel Version 5.0
- Arc-View Version 2.0

Some familiarity with these two programs and Windows is assumed.
File management is critical. You will be working with many different data files with similar names, different versions of the same file, and across different machines and programs. My suggestions for file and disk management have evolved over hundreds of hours of working with these data files, so you may well want to stay with a similar system. Work should be performed while fully caffeinated.

There are five main parts involved in processing these files:

1. Copying the files to the hard drive
2. Cleaning the files in Excel
3. Importing the files to Access and querying
4. Calculations in Excel
5. Creating a summary file and importing to Arc-View

For this example, we'll use the 1991-1994 data files (sixteen disks total) for the Toledo ODF District, Lincoln and Benton Counties, Oregon.

* * * * *

PART I: COPYING THE FILES TO THE HARD DRIVE

A. Create directories and copy the data from the floppies onto the hard drive.
1. Go to DOS or the Windows File Manager.
2. Under the C root directory, make a directory called TOLEDO.
4. Under each of these directories, create four more subdirectories: WINTER, SPRING, SUMMER and FALL.
5. Insert the FACTS data floppy disc for winter (1-1 to 3-3) 1991. Using the Windows File Manager, copy TABLE1.DBF, TABLE2.DBF, and TABLE3.DBF to the directory C:TOLEDO\1991\WINTER.
6. Insert the spring 1991 floppy disc, and copy TABLE1.DBF, TABLE2.DBF, and TABLE3.DBF to C:TOLEDO\1991\SPRING.
7. Repeat for the other 14 discs, copying them to their appropriate directories on the C: drive.

You are done with part 1.
PART II: CLEANING THE FILES IN EXCEL

A. Cleaning TABLE1 (deleting extraneous data fields)
There are many extra data fields in all three tables which are not necessary for herbicide analysis. They should be deleted for simplicity in the analysis, to speed processing time and save disk space. For the files to be properly joined later, it is important that the field names be exactly the same in all the files. Move the fields to the proper order by cutting and inserting them, if necessary. See the sample spreadsheets below for examples of the field order.

1. Load Excel.
2. Open C:\TOLEDO\1991FALL\TABLE1.DBF.
3. Insert a column before column A. Title it loc-code. In cell A2, type 1991fal-tol. Fill down the entire column with this value.
4. Insert a column before column C. Title it season. In cell C2, type in fall. Fill down the entire column with this value.
5. Change the decimal places in the header notifnumb from four to zero.
6. Change the header countynam to county.
7. Select the entire worksheet, and autosize the column width.
8. Delete the following columns from table1.dbf. Not all these columns may be present in the particular file you are working with. Delete:

    notifdist, revenuenum, noticefil, equipperm, rightofw, noticeof, district, daterecei, timerecei, prior, x3a, x3b, x3c, x3d, opfirst, opmid, oplast, opbusines, opstreet, opcity, opstate, opzip, opphone, lomid, lostreet, locity, lostate, lozip, lophone, tofirst, tomid, tolast, tobusines, tostreet, tocity, tostate, tozip, and tophone.

When you are finished deleting fields, table1 should look exactly like this:

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOC-CODE</td>
<td>NOTIFNUMB</td>
<td>SEASON</td>
<td>YEAR</td>
<td>COUNTY</td>
<td>OFFICE</td>
<td>LOFIRST</td>
<td>LOLAST</td>
<td>LOBUSINES</td>
</tr>
</tbody>
</table>

Table 2: TABLE1 after cleaning

9. Save file as a Microsoft Excel Workbook, giving it a .XLS extension.

B. Cleaning TABLE2 (deleting extraneous data fields)
Open TABLE2.DBF, and make the following changes:
1. Insert a column before column A. Give it the header *loc-code*.
2. In cell A2, type **1991fal-tol**. Fill down the entire column with this value.
3. Change the decimal places in the column *notifnumb* from four to zero.
4. Change the header *unitnumbe* to *unit*.
5. Autosize the entire worksheet.
6. Delete the following columns from table2.dbf:

```
method, fp, act2, act3, act4, act5, feet, mbf, startdate, enddate, wcode, scode, tcode, spec1,
spec2, spec3, spec4, and spec5.
```

When you are finished deleting fields, table2 should look exactly like this:

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOC-CODE</td>
<td>NOTIFNUMB</td>
<td>UNIT</td>
<td>ACT1</td>
<td>ACRES</td>
</tr>
</tbody>
</table>

**Table 3:** TABLE2 after cleaning

7. Save the file as a Microsoft Excel Workbook, giving it a .XLS extension.

**C. Cleaning TABLE3 (changing data fields)**

Open TABLE3.DBF, and make the following changes:

1. Insert a column before column A. Title it *loc-code*.
2. In cell A2, type **1991fal-tol**. Fill down the entire column with this value.
3. Change the decimal places in the header *notifnumb* from four to zero.
4. Change the header *unitnumbe* to *unit*.

When you are finished changing fields, table3 should look exactly like this:

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H-W</th>
</tr>
</thead>
<tbody>
<tr>
<td>LOC-CODE</td>
<td>NOTIFNUMB</td>
<td>UNIT</td>
<td>DETAIL</td>
<td>TOWNSHIP</td>
<td>RANGE</td>
<td>SECTION</td>
<td>NWNW-SESE</td>
</tr>
</tbody>
</table>

**Table 4:** TABLE3 after cleaning

5. Save the file as a Microsoft Excel Workbook, giving it a .XLS extension.

You should now have six files in TOLEDO\1991FALL: the three original .DBF files, and the cleaned .XLS files. Delete all the original .DBF files from the TOLEDO\1991FALL directory.
Continue for TABLE1, TABLE2, and TABLE3 in all the other TOLEDO subdirectories. There will be a total of 48 files to clean [(three files per season) x (four seasons per year) x (four years)]. This is a bit tedious, but necessary.

You are done with cleaning the files.

You are done with Part II.

* * * * * * * * *

PART III: IMPORTING THE FILES INTO ACCESS AND QUERYING

A. Open Access and import files.
1. Open Access.
2. Create a new database. Title it Toledo.
3. From File, select Import.
4. From the Data source window, select Microsoft Excel 5.0 files.
5. In the Select file window, move through the directory tree until you get to C:\TOLEDO\1991\FALL.
6. Select TABLE1.XLS.
7. Select the box next to First Row Contains Field Names.
8. Select the box next to Create New Table.
9. Click OK. The file will be imported to the Access database.
10. Now, select TABLE1.XLS from C:\TOLEDO\1991\SPRING. Select the box next to, First Row Contains Field Names, but this time, select the box next to Append to Existing Table. Be sure TABLE1.XLS is in the existing table box. Click OK. The table1 file for spring will be appended onto the end of the table1 for fall in the database.
11. Continue this same procedure for all of the 16 table1 files in the four years of the TOLEDO directory, importing the files and appending them onto table1 in Access. When you have imported the last table (winter 1994), close the import window to return to the Access database window.

B. Importing TABLE2 and TABLE3
The above steps are repeated for table2 and table3.
1. Go to the Access database window.
2. From File, select Import.
3. Move through the directory tree until you get to C:\TOLEDO\1991\FALL.
4. This time, select TABLE2.XLS.
5. Select the box, First row contains field names.
6. Select the box, Create new table.
7. Click OK. The file will be imported to the Access database.
8. Now, select table2.xls from C: \ TOLEDO \ 1991 \ SPRING.
9. Select the box, First row contains field names, and select the box, Append to existing table.
10. This time, click the arrow in the table box to access the drop down table selection, and select table2. Click OK. The table2 file for spring will be appended onto the end of the table2 for fall in the database, just as above.
11. Continue for all of the 16 table2 files in the four years of the TOLEDO directory, importing the files and appending them onto the table2 in Access. When you have imported the last table (winter 1994), close the import window to return to the Access database window.
12. Repeat steps 1-9 for table3. When you are done, you will have a single database, Toledo, made up of three tables: table1, table2, and table3.

C. Adding a primary key
1. From the Table module in Access, open table1 in datasheet view.
2. Select the fields (which are displayed as rows) loc-code and notifnumb.
3. Click on the primary key icon to set these fields as the primary keys.

D. Querying
1. From the main database window in Access, select the Query module.
2. Select New. Do not use the wizard.
3. Add table1, table2 and table3 to the query window.
4. From table1, select all fields. Drag them to the query box.
5. From table2 select unit, acres, and act1. Drag them to the query box.
6. From table3 select detail, township, range, section, and all sixteen 1/4 1/4 section locations. Drag them to the query box.
7. Under act1, type 4A in the criteria row.
8. Under county, type LINCOLN in the criteria row.
9. Click on the datasheet view to see the results of the query.

The query will select all the 4a (herbicide spray) records for Lincoln County. Close the query. Save as LINC91-94.

D. Export to Excel
1. Select the query you just made, LINC91-94.
2. From File, choose Export. Choose file type Excel 5.0.
3. Choose the path, C: \ TOLEDO.
4. Click OK. The LINC91-94 query will be converted to an Excel spreadsheet file, and saved under C: \ TOLEDO.
You are done with part III.

* * * * * *

PART IV: CALCULATIONS IN EXCEL

A. Add record numbers
1. Open LINC91-94.XLS.
2. Insert a new column before column A.
3. Give it the header rec#. Fill this column with ascending record numbers.

B. Sort by acres and delete records with no acreage value
1. Sort the entire worksheet on acres.
2. After the sort, records with an empty value in the column acre should all have moved to the end of the file.
3. Delete these records from the file.

C. Sort by rec#
Repeat steps 1-4 in the above step, this time sorting by the column rec#. This returns the records to their original order.

D. Add new record numbers
After you delete the zero acreage records, the record numbers will be all discombobulated.
To fix them:
1. Delete the values in the column rec#.
2. Fill down once again with new record numbers.

E. Column addition
Columns need to be added so additional data and calculations may be included in the spreadsheet. Add six columns, give them the following headings, and place them between the indicated columns (use Insert, Columns, from the toolbar menu). See Table A-2.

1. ac/sec (to the left of township; to the right of detail)
2. det-unit (to the left of ac/sec; to the right of detail)
3. 1/4-notifunit (to the left of det-unit; to the right of detail)
4. a column with no heading (to the left of 1/4-notifunit; to the right of detail)
5. trscode (to the left of nene and to the right of section)
6. tot1/4 (to the left of timbersal; to the right of sese)
Table 5. Column headings before and after new column insertion.

C. Calculate a value for trscode
1. Go to the first record in the blank column trscode.
2. Type in the function \(=\text{concatenate}(Q3,R3,S3)\) [where column Q is township, column R is range, and column S is section]. This function will lump the township, range and section together in a single column.
3. Drag down on the cell fill handle, filling every cell in the column with the function.
4. Copy, Paste Special, Values, over the column trscode to retain the values.

F. Sum the “X” marks in the sixteen 1/4 1/4 section columns
1. Go to the first 1/4 1/4 column, which should be nene (the first column after the column section). Make a note of the column letter; in our case, it’s U. Go to the last 1/4 1/4 section column, which should be sese. Note this column letter, which in this case is AJ.
2. Now, go to the first record in the column totl/4, and type in the function: \(\text{countif}(U2:AJ2, "X")\). This will count all the “X” values in 1/4 1/4 columns, and print that value in the column to1/4.
3. Select this function, and drag down with the fill handle to fill every cell in the column.

NENE NENW NESW NESW NWNE NWNW NWSE NWSE SWNE SWNW SWSE SENE SENW SESW SESE TO1/4

<p>| | | | | | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
</tbody>
</table>

Table 6: “Countif” example

G. Copy the column to1/4 and Paste Special
Next, move the to1/4 column to a more useful part of the file.
1. Select the entire to1/4 column.
2. Copy the column.
3. Select the blank column which follows the column detail.
4. Click Paste Special, Values.
5. Add a title to this column, total1/4.

H. Use the Data Subtotal command to subtotal the total 1/4 1/4 sections per notifnumb
1. Select the entire worksheet.
2. From Data, select Subtotals.
3. If you get the "No headers detected. Assume top row of selection is header row?" message, click OK. Fill in the dialogue box as follows:

- At Each Change in: notifnumb
- Use Function: sum
- Add subtotal to: total1/4

Click Summary Below Data box to off (no “x”), and click OK.
The total number of 1/4 1/4 sections per notification number will appear on a line above the first occurrence of that notification number.

I. Calculate a value for the column 1/4-notifnumb.
This is simply the subtotaled value from step G put into a column of its own.
1. Go to the first row of the second notifnumb.
2. Type in the function: =L6 [where L6 is the subtotaled total1/4 value for that notification number].
3. Type Ctrl+C to copy the function.
4. Scroll down the file, pasting the function with Ctrl+V at the first line of every new notification number.
5. When you have finished the file, select the column and copy with Ctrl+C C.
6. Choose Paste Special, choose Values, and select OK.
7. This pastes the calculated values over the function, so the values are not lost when the subtotals are removed.

<table>
<thead>
<tr>
<th>ACRES</th>
<th>NOTIFNUMB</th>
<th>UNIT</th>
<th>DETAIL</th>
<th>TOTAL1/4</th>
<th>1/4NOTIFNUMB</th>
</tr>
</thead>
<tbody>
<tr>
<td>99</td>
<td>52100802</td>
<td>1</td>
<td>1</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>34</td>
<td>52102039</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>7</td>
</tr>
<tr>
<td>34</td>
<td>52102039</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>115</td>
<td>52102039</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td>115</td>
<td>52102039</td>
<td>2</td>
<td>2</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>120</td>
<td>52102357</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>5</td>
</tr>
<tr>
<td>120</td>
<td>52102357</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>55</td>
<td>52102357</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

Table 7: “1/4 notifnumb” example
J. Remove subtotals
The subtotals have done their part. To remove them,
1. Select the entire worksheet.
2. From Data, select Subtotals.
3. If you get the “No headers detected. Assume top row of selection is header row?” message, click OK.
4. Select Remove All, and the subtotals will disappear.

K. Calculate the value for the column det-unit
The det-unit value represents the closest possible approximation of the acres represented by a single “X” for a given notification number.
1. Go to the column det-unit, in the first data row (row 3).
2. Type in the function, =(I3/M3) [where column I is acres and column M is 1/4notifnumb]
3. This divides the acres for a notifunit by the total number of 1/4 1/4 section locations for that notifunit.
4. Select this cell where the function is typed.
5. Drag down to fill the entire column with this function. Ignore the “#DIV/0” error message for now.
6. Select the column det-unit. Copy, Paste Special, Values, over the entire column, to retain cell values.

L. Fill the column det-unit with the proper values
1. Select the column det-unit. Select the “increase decimal places” icon on the toolbar to increase the decimal places from zero to one.
2. Go to the first record in the column det-unit. Select the value in that cell (row 2).
3. If there is a “#DIV/0” error message in the cell below it, drag the value down with the fill handle, overwriting the error message.
4. Stop when you come to cell with a new value, which corresponds to a new notifnumb.
5. Select this new value, and repeat. Continue for the entire file. There should be a value in every cell of the column det-unit when you are done.

<table>
<thead>
<tr>
<th>ACRES</th>
<th>NOTIFNUMB</th>
<th>UNIT</th>
<th>DETAIL</th>
<th>TOTAL</th>
<th>1/4NOTIFNUMB</th>
<th>DET-UNIT</th>
</tr>
</thead>
<tbody>
<tr>
<td>99</td>
<td>52100802</td>
<td>1</td>
<td>1</td>
<td>5</td>
<td>5</td>
<td>19.8</td>
</tr>
<tr>
<td>34</td>
<td>52102039</td>
<td>1</td>
<td>1</td>
<td>5</td>
<td>7</td>
<td>4.9</td>
</tr>
<tr>
<td>34</td>
<td>52102039</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>7</td>
<td>4.9</td>
</tr>
<tr>
<td>115</td>
<td>52102039</td>
<td>2</td>
<td>1</td>
<td>8</td>
<td>14.3</td>
<td></td>
</tr>
<tr>
<td>115</td>
<td>52102039</td>
<td>2</td>
<td>2</td>
<td>5</td>
<td>14.3</td>
<td></td>
</tr>
<tr>
<td>120</td>
<td>52102357</td>
<td>1</td>
<td>1</td>
<td>5</td>
<td>24.0</td>
<td></td>
</tr>
<tr>
<td>120</td>
<td>52102357</td>
<td>1</td>
<td>2</td>
<td>5</td>
<td>24.0</td>
<td></td>
</tr>
<tr>
<td>55</td>
<td>52102357</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>55.0</td>
<td></td>
</tr>
</tbody>
</table>

Table 8: “det-unit” example

The function =(H3/L3) is entered here. For the first record, the 99 acres in the spray permit is divided into five 1/4 1/4 sections, giving a mean value of 19.8.
M. Calculate the value for the column ac/sec
This value represents the closest possible approximation of the acreage sprayed per section per year.
1. Select the first record of the ac/sec column.
2. Type in the function \(= (L_3 \times N_3)\) [where L is the column total/4 and N is the column det-unit.]
3. Select this cell, and drag it down to fill the entire column with the formula.
4. Copy, Paste Special, Values over the column to retain the values.

The function =PRODUCT(L3,N3) is entered here. For the first notifunit, the total 1/4 1/4 value (5) is multiplied by the det-unit value (19.8) to give a spray acreage for section 2 of 99 acres.

<table>
<thead>
<tr>
<th>ACRES</th>
<th>NOTIFNUMB</th>
<th>UNIT</th>
<th>DETAIL</th>
<th>TOTAL/4</th>
<th>1/4NOTIFUNIT</th>
<th>DET-UNIT</th>
<th>AC/SEC</th>
<th>TOWNSHIP</th>
<th>RANGE</th>
<th>SECTION</th>
</tr>
</thead>
<tbody>
<tr>
<td>99</td>
<td>52100802</td>
<td>1</td>
<td>1</td>
<td>5</td>
<td>5</td>
<td>19.8</td>
<td>99</td>
<td>08N</td>
<td>08W</td>
<td>02</td>
</tr>
<tr>
<td>34</td>
<td>52102039</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>7</td>
<td>4.9</td>
<td>15</td>
<td>04N</td>
<td>09W</td>
<td>01</td>
</tr>
<tr>
<td>34</td>
<td>52102039</td>
<td>1</td>
<td>2</td>
<td>4</td>
<td>4.9</td>
<td>15</td>
<td>15</td>
<td>04N</td>
<td>09W</td>
<td>12</td>
</tr>
<tr>
<td>115</td>
<td>52102039</td>
<td>2</td>
<td>1</td>
<td>3</td>
<td>8</td>
<td>14.3</td>
<td>43</td>
<td>05N</td>
<td>05W</td>
<td>19</td>
</tr>
<tr>
<td>115</td>
<td>52102039</td>
<td>2</td>
<td>2</td>
<td>5</td>
<td>14.3</td>
<td>72</td>
<td>72</td>
<td>05N</td>
<td>05W</td>
<td>18</td>
</tr>
<tr>
<td>120</td>
<td>52102357</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>5</td>
<td>24.0</td>
<td>96</td>
<td>08N</td>
<td>06W</td>
<td>23</td>
</tr>
<tr>
<td>120</td>
<td>52102357</td>
<td>1</td>
<td>2</td>
<td>1</td>
<td>24.0</td>
<td>24</td>
<td>24</td>
<td>08N</td>
<td>06W</td>
<td>24</td>
</tr>
<tr>
<td>55</td>
<td>52102357</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>55.0</td>
<td>55</td>
<td>06N</td>
<td>07W</td>
<td>32</td>
</tr>
</tbody>
</table>

Table 9: “ac/sec” example
You now have, in one file, sorted in ascending notification number: 1) every herbicide spray record; 2) the section and 1/4 1/4 sections affected by that spray; 3) a landowner; and 4) an acreage value; for one ODF district, for four years. You do not have to print this file. The column headings and letters should look like:

<table>
<thead>
<tr>
<th>A</th>
<th>REC_#</th>
<th>T</th>
<th>TRSCODE</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>LOC-CODE</td>
<td>U</td>
<td>NENE</td>
</tr>
<tr>
<td>D</td>
<td>NOTIFNUMB</td>
<td>V</td>
<td>NWNW</td>
</tr>
<tr>
<td>E</td>
<td>SEASON</td>
<td>W</td>
<td>NESW</td>
</tr>
<tr>
<td>F</td>
<td>YEAR</td>
<td>X</td>
<td>NESE</td>
</tr>
<tr>
<td>G</td>
<td>COUNTY</td>
<td>Y</td>
<td>NWNE</td>
</tr>
<tr>
<td>H</td>
<td>OFFICE</td>
<td>Z</td>
<td>NWNW</td>
</tr>
<tr>
<td>I</td>
<td>ACRES</td>
<td>AA</td>
<td>NWSW</td>
</tr>
<tr>
<td>J</td>
<td>UNIT</td>
<td>AB</td>
<td>NWSE</td>
</tr>
<tr>
<td>K</td>
<td>DETAIL</td>
<td>AC</td>
<td>SWNE</td>
</tr>
<tr>
<td>L</td>
<td>TOTAL1/4</td>
<td>AD</td>
<td>SWNW</td>
</tr>
<tr>
<td>M</td>
<td>1/4NOTIFNUMB</td>
<td>AE</td>
<td>SWSW</td>
</tr>
<tr>
<td>N</td>
<td>DET-UNIT</td>
<td>AF</td>
<td>SWSE</td>
</tr>
<tr>
<td>O</td>
<td>AC/SEC</td>
<td>AG</td>
<td>SENE</td>
</tr>
<tr>
<td>P</td>
<td>LOBUSINES</td>
<td>AH</td>
<td>SENW</td>
</tr>
<tr>
<td>Q</td>
<td>TOWNSHIP</td>
<td>AI</td>
<td>SESW</td>
</tr>
<tr>
<td>R</td>
<td>RANGE</td>
<td>AJ</td>
<td>SESE</td>
</tr>
<tr>
<td>S</td>
<td>SECTION</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 10: Final column headings

PART V: CREATING A SUMMARY FILE AND IMPORTING TO ARC-VIEW

We now have several acreage values associated with a single section. These must be subtotaled by section to get a single acreage value per section from which to create a map.

A. Sort by trscode
   1. Select the entire worksheet, and sort by trscode.

B. Move the column ac/sec
   1. Cut the column ac/sec and insert before the column nene and after the column trscode.

C. Add a new column, ac/91-94
   1. Insert a new column before the column nwnw and after the column ac/sec.
   2. Give this new column the header, ac/91-94.
D. Use Data Subtotal to calculate a value for ac/91-94
1. Select only the columns trscode and ac/sec.
2. From Data, select Subtotals.
   
   At Each Change in:          trscode
   Use Function:               sum
   Add Subtotal to:            ac/sec

3. Be sure the Summary Below Data box is off (no "x")
4. This will sum all the acreage values for each separate section.

E. Copy and paste the ac/sec subtotals
1. Go to the second record in the column ac/91-94; in this case it’s row 8.
2. Type in the function, =(O7) [where cell O7 is the subtotal for that trscode].
3. Hit Ctrl+C to copy the function, and then scroll down the page to the next new trscode.
4. Hit Ctrl+V to paste the function in the first occurrence of a new trscode number.
5. Continue for the entire file. This will take awhile.
6. Copy, Paste Special, Values to retain the values after the subtotals are removed.
7. Remove the subtotals.

F. Create a simplified file from which to map
1. Save the file to a new name, e.g., LINCMAP.XLS.
2. Delete every column except township, range, section, trscode, and ac-91-94.
3. Delete every row which does not have a value in the column ac-91-94.
   This process creates a simple, easy to read file with the location and acreage values necessary for mapping. This may be joined with the PAT of an existing Arc-Info coverage, or the acreage values may be used to manually draw on a transparency to create an overlay for a hard copy map.

Type Ctrl+S to save your work.

You are finished with the multi-year summary. You now have, in ascending township / range /section order, a single acreage value of herbicide use for a given section. These values may now be used to map acreage spray by section, or to create the figures such as those seen in Figures 5-11. If you want to print . . .

Printing Suggestions

Page Setup
1. From File, select Page Setup. Select Sheet. In the Print Titles box, Select Rows to Repeat at Top. Select row 1. "$1" should appear in the "Rows to Repeat at Top" box.
This will print the column headings at the top of every page, rather than just on the first one.

2. In the Print box, be sure the Gridlines box is x’ed.
3. Click Header/Footer. Click Custom Header. Add the following header information:

<table>
<thead>
<tr>
<th>Left Section:</th>
<th>Center Section</th>
<th>Right Section</th>
</tr>
</thead>
<tbody>
<tr>
<td>Herbicide Spray data</td>
<td>&amp;[File]</td>
<td>&amp;[Date]</td>
</tr>
<tr>
<td>ODF Toledo District</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1991-1994 TOTALS</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

4. Finally, click Page. In the Orientation box, choose Landscape.

Print Preview, margin adjustment and printing

1. Select Print Preview. Wait a moment while a preview window comes up. Select Margins.
2. Click Next or hit type Page Down to scroll through your file. If it doesn’t all print neatly on one page, or if the headers are obscured, adjust the margins by dragging them left, right, up or down to maximize the number of columns which fits on one page.
3. After adjusting the margins and it all looks good, click Print, and then <enter>.
Appendix B: Arcplot Map Macro (Lincoln County)

&rem This macro creates a .PLT file for plotting herbicide use in Lincoln County

disp 4
linc2
pagesize 34 22
linesym 69
box .5 .5 30 21
mapextent linc10
maplimits .5 .5 22 19.5

&rem draw and shade polygons
linesym 1
polys linc10
resel linc10 polys tot_ac > 0 and tot_ac <= 64
polycontext linc10 tot_ac
penspeed 75
polygonshades linc10 7
asel linc10 polys

resel linc10 polys tot_ac > 64 and tot_ac <= 128
polycontext linc10 tot_ac
penspeed 75
polygonshades linc10 11
asel linc10 polys

resel linc10 polys tot_ac > 128 and tot_ac <= 256
polycontext linc10 tot_ac
penspeed 75
polygonshades linc10 20
asel linc10 polys

resel linc10 polys tot_ac > 256 and tot_ac <= 384
polycontext linc10 tot_ac
penspeed 75
polygonshades linc10 24
asel linc10 polys

resel linc10 polys tot_ac > 384 and tot_ac <= 512
polycontext linc10 tot_ac
penspeed 75
polygonshades linc10 66
asel linc10 polys

resel linc10 polys tot_ac > 512
polycontext linc10 tot_ac
penspeed 75
polygonshades linc10 70
asel linc10 polys

&rem add text
move 22 18
textsym 41
textsize .8
text Forestry
move 22 16.5
text 'Herbicide'
move 22 15
text 'Use'
textsym 61
textsize .5
move 22 13
text 'Clatsop County, OR'
move 22 12
textsize .25
text 'Data Source: Oregon Dept. of Forestry'
move 22 11.3
text 'Permit Notifications, Jan. 1990 to June 1994'
textsize .2
move 22 2.2
text 'One section is approximately one square mile'

line 28.5 1.5 28.5 3
line 28.5 3 28.25 2.75
move 28.3 3.25
textsize .5
text 'N'
textsym 33
textsize .25
keybox 1.5
keypos 22 10
keys sep .5 .5
keyshade keyshade.key