A BOTANICAL INVENTORY OF THE ROCKY FLATS AEC SITE:
Mapping Methods and Preliminary Maps

Technical Progress Report

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A BOTANICAL INVENTORY OF THE ROCKY FLATS AEC SITE:
MAPPING METHODS AND PRELIMINARY MAPS

TECHNICAL PROGRESS REPORT (COO-2371-5)

ABSTRACT

This Technical Progress Report represents a small but important part of the overall progress and research effort of this contract. It outlines the methods used to produce one 1:12,000 colored vegetation map of the Rocky Flats site and its surrounding area and six black and white 1:500 vegetation maps of intensively studied experimental plots. These maps are already being used by various researchers and it is appropriate that the mapping methods be detailed prior to the final contract report so that their use may be optimised.

April 28, 1976

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A BOTANICAL INVENTORY OF THE ROCKY FLATS AEC SITE:
MAPPING METHODS AND PRELIMINARY MAPS
TECHNICAL PROGRESS REPORT (COO-2371-5)

Introduction:

This report is an account of the methods used to map the vegetation at the Rocky Flats site. The methods are described here because our maps have already been distributed widely to users (Rockwell International, and ERDA investigators) of the Rocky Flats sites who have asked for details of our methods. Six vegetation maps have been made and are provided in the enclosed envelopes. One map at a scale of 1:12,000 has been printed in color. It provides an overview of the Rocky Flats installation and its environs. This map allows the entire Rocky Flats area to be appreciated at a glance, the selection of comparable areas for classic experimental design, and long-term monitoring of vegetation change. The final scale of 1:12,000 was chosen for this map with topographic information provided by 50 foot (~ 15 meter) contour intervals. The five remaining vegetation maps give specific details of experimental or manipulated areas which are of special interest to the operators of the site and the various scientific investigators using the site (Caine and Morin 1975, Whicker 1975). These maps are presented at a scale of 1:500 with contour intervals of 1 meter. They show sufficient detail to allow an interpretation of vegetation type and estimates of plant cover to be made for specific sites such as soil erosion plots, micrometeorological installations, and small mammal trapping grids. Map 1 shows the location of the 1:500 maps.

Mapping theory:

A vegetation map is a qualitative description of the spatial distribution

Map 1. Location of the five 1:500 vegetation and 1-meter topographic maps.

of plant associations or communities. A useful definition of plant communities is that they are "subdivisions of a vegetation cover. Wherever the cover shows more or less obvious spatial changes, one may distinguish a different community" (Mueller-Dombois and Ellenberg, 1974, p.4). A list of possible causes of these changes would include the following: "spatial changes in species composition, changes in spacing and height of plants, changes in growth form or life form of plants, or seasonal plant responses of other vegetation properties" (Mueller-Dombois and Ellenberg, 1974, p.4).

Vegetation mapping is a form of classification which has value to various users in that the map, combined with map unit descriptions, may be used without a comprehensive knowledge of the vegetation. Like all classification, vegetation mapping seeks to compartmentalize the vegetation into discrete units. Each of the units is an abstract representation of one or more homogeneous plant communities. A plant community is "a combination of plants that are dependent on their environment and influence one another and modify their own environment" (Mueller-Dombois and Ellenberg, 1974, p.27). Unlike "objective" quantitative classification, a vegetation map may be subjectively based on one or a variety of vegetation characteristics which are incorporated to different degrees at the discretion of the mapper. Therefore, it is often difficult but necessary to verbalize what combination of characteristics was used in constructing a particular map.

A widely-used method of vegetation mapping in the United States is that of Kuchler (1967, pp.266-276). Briefly, this method entails the following steps: 1) compiling a floristic inventory of the map area; 2) determining the approximate number and size of the prospective map units; 3) outlining the areas of different shades on black-and-white aerial photographs of the area, in the laboratory; 4) field verifying each outlined area to determine

its vegetation composition, environmental characteristics, and homogeneity; 5) classifying the areas into the desired number of map units on the basis of any number of characteristics noted in the previous step. "Objective" quantitative classification may be incorporated at this step and will serve to define what the basis for the map actually is, and make repetition and comparisons possible; and, finally, 6) constructing the final version of the map at the desired scale. It should be noted that once the field verifications and summaries are made, a different map based on a different classification may be compiled easily in the laboratory, based on the field observations, when this method is used.

It was originally intended that Kuchler's method, as outlined above, would be followed as much as possible in mapping the vegetation of Rocky Flats. Two important deviations from this method had to be made. The first involved drawing unit boundaries on photographs while the mapper was in the field rather than in the laboratory as stated in step, above. The second involved omitting a portion of step 4, above. While almost all areas outlined on a map were field verified (since this was necessary for drawing boundaries), the various ecological characteristics of each individual area were not recorded. This would have been much too time-consuming for the purposes of this program. Instead, each area was given a number corresponding to a mapping unit with which its floristic composition was most readily identified. It was stated in step 5 that objective quantitative classification could be carried out before field mapping is done and advantages for doing this were pointed out. When time is a limiting factor, as it was at Rocky Flats, this is usually not feasible. Kuchler (1967, p. 98) has made the following statements on this subject:

"An author desiring to study the vegetation of any given area will obtain particularly satisfactory results if he prepares a detailed vegetation map as a first step and bases his map on aerial photographs.

He will then base his investigations on the map and on the observations he made in preparing it. To prepare a vegetation map after the study has been completed is to deprive oneself of the most enlightening study method yet devised."

Scale and unit selection

Map scales should be determined on the basis of for whom or for what purpose the map is being made. The scale of 1:12,000 is ideal for overview purposes while the scale of 1:500 permits detailed interpretation of points which can be actually located in the field. Final cartographic detail is partly a function of scale and cartographic and field skills. The smallest area on the 1:12,000 map is about a one millimeter square; this represents a field area of a 12 x 12 meter area. On the 1:500 maps the smallest field areas recognised are about 1.5 x 1.5 meters. The 1:500 map could be reduced to scales of 1:1,000 or even 1:1,500 without any loss of detail or accuracy.

Only conventional black and white air photography was used in the study. The 1:12,000 map was initially drawn as an overlay of a 1:7,920 photograph which was taken in the summer of 1973 by the National Aeronautics and Space Administration. Topographic information was derived from the United States Geological Survey map which includes Rocky Flats. This source map had a scale of 1:24,000 with 10-foot contour intervals. The 1:500 maps were drawn as overlays over photographs of the same scale. These photographs were taken by a local photogrammetry company to our specifications. Topographic overlays of the photographs with one meter contour intervals were supplied by the same company.

A species inventory of vascular plants, bryophytes, and lichens of the Rocky Flats plant site proper was compiled in summer 1973 under the present contract (Weber et al. 1974). Plant collections from the remaining

peripheral areas were made by Věra Komárková in summer, 1974. A preliminary survey of the vegetation resulted in a decision that approximately twelve mapping units would adequately represent the vegetation. Examination of the photography led to the decision that many more types of plant communities could be identified in the field than could be distinguished on the photographs. This potential problem was pointed out by Mueller-Dombois and Ellenberg (1974, pp. 425, 426): "Vegetation units defined by their total floristic composition cannot always be clearly recognized on air photos because the structure visible on air photos is primarily conditioned by the dominant species and their developmental status." Because of the desired map scales and because of the total floristic composition basis of the maps, a modification of Kùchler's method was utilized in mapping most of the Rocky Flats area. The modification involved establishing and verifying community boundaries on the aerial photographs directly in the field, based on a subjective classification of changes in floristic species composition. Kùchler's method was used where ground access to private property within the mapping area was not granted. Not all of these restricted areas were visited although some field verification was made from a distance. Units were combined and additional ones were incorporated during the mapping process. Sixteen final mapping units for the color map were selected for visual vegetational homogeneity. They are illustrated and briefly described in Figures 1 to 16. A few additional units were added for the 1:500 map series. It should be noted that both disturbed and non-disturbed plant communities are represented as mapping units. Some ecologists consider disturbed vegetation to be successional stages of non-disturbed vegetation and that it should be classified with its related non-disturbed or "natural" unit (Mueller-Dombois and Ellenberg, 1974, p. 14). This weighting of non-disturbed vegetation would be impractical at Rocky Flats for several reasons: 1) there is very little totally non-disturbed or "natural"

Figure 1.
 DRY, *BUCHLOE DACTYLOIDES*--*MEDICAGO SATIVA*, PASTURE.
 This vegetation unit occurs in patches on dry, heavily-grazed pediment. It covers approximately 2.5 percentage of the total area. *Buchloe dactyloides* forms a compact sod and is only a few centimeters high. *Medicago sativa* and *Gutierrezia sarothrae* form an open stand and are about 0.5 meters in height.

Figure 2.

DRY, *BUCHLOE DACTYLOIDES*--*ARNICA FULGENS*, PASTURE.
 This vegetation type covers much of the dry, heavily-grazed pediment in the eastern portion of the area. It comprises approximately 16.4 percentage of the total area. *Buchloe dactyloides* forms an almost continuous sod. *Arnica fulgens* and *Bromus tectorum* are scattered throughout the area.

Figure 3.

DRY, *KOELERIA MACRANTHA*, *AGROPYRON TRACHYCAULUM*, PRAIRIE. This vegetation unit is found on pediment within the barbed wire fence boundary of the site where grazing does not occur. It covers approximately 7.8 percentage of the total map area. Grasses are dominant and range in size from 0.25 meters to nearly one meter. Common grasses include *Koeleria macrantha*, *Agropyron trachycaulum*, *Muhlenbergia montana*, and *Schizachyrium scoparium*--an indicator of mid-grass prairie. Herbs are represented by *Artemisia ludoviciana* and *Heterotheca villosa* (left, A), and *Antennaria parviflora* (left and bottom, B). Succulents include *Sedum lanceolatum* (right, B) and *Opuntia compressa* (top, B).

Figure 4.

DRY, *CARDUUS NUTANS*--*BROMUS TECTORUM*, BARRENS.

This vegetation type occurs in patches on disturbed soil throughout the area. It covers approximately 3.2 percentage of the total area. Two distinct facies are represented. *Carduus nutans* may reach over one meter in height and forms open stands on dry soil with a dense understory of *Bromus tectorum* (A). *Cirsium arvense* is smaller in stature and forms more dense stands on moist valley-sides and in meadows (B).

Figure 5.

DRY, *STIPA COMATA*--*KOELERIA MACRANTHA*, PRAIRIE.

This vegetation type approximates native prairie and covers areas of relatively undisturbed pediment. It comprises approximately 7.1 percentage of the total area. The dominant and most conspicuous species is *Stipa comata*, a native prairie grass which may grow to one meter in height. Other indigenous grasses include *Koeleria macrantha*, *Andropogon gerardii*, and *Sitanion longifolium*.

Figure 6.
 DRY, *HETEROTHECA VILLOSA*--*BUCHLOË DACTYLOIDES*, PASTURE.
 This vegetation type is found on rocky ridges and pediment. It covers approximately 8.4 percentage of the total area. *Heterotheca villosa* is a conspicuous yellow-flowered composite which grows to a height of about 0.25 meters and forms an open, spreading cover. Dominant grasses in this type include *Buchloë dactyloides*, *Bouteloua curtipendula* and *Bromus tectorum*.

Figure 7.

MOIST, *SYMPHORICARPOS OCCIDENTALIS*--*POA COMPRESSA*, LOW SCRUB. This vegetation type is scattered in discrete stands along many of the valley-sides. It covers approximately 0.7 percentage of the total area. *Symphoricarpos occidentalis* and *Symphoricarpos oreophilus* form a dense scrub about 0.5 meters high. Many grasses including *Poa compressa*, *Agropyron trachycaulum*, and *Bromus tectorum* grow at the margins of the stands but there is virtually no understory within the stands.

Figure 8.

MOIST, *AGROPYRON TRACHYCAULUM*--*POA COMPRESSA*, MEADOW. This vegetation type is found on many of the valley-sides and bottoms. It covers approximately 22.9 percentage of the total area. *Agropyron trachycaulum* grows to nearly a meter in height in the drier areas along with *Bromus tectorum*, *Poa pratensis*, and *Tragopogon dubius*. *Poa compressa* is a shorter grass which often dominates the wetter slopes and valley-bottoms.

Figure 9.

WET, *SALIX EXIGUA*--*BARBAREA ORTHOCERAS*, STREAMBANK.

This vegetation occurs along the larger streams and covers approximately 0.7 percentage of the total area. *Salix exigua* often grows to a height of two meters and, with other shrubs, provides cover for the deer which inhabit the area. *Cirsium arvense* often forms a dense understory. Other species which sometimes are present include *Barbarea orthoceras*, *Epilobium adenocaulon*, and *Fallopia convolvulus*.

Figure 10.

WET, *CAREX NEBRASKENSIS*--*JUNCUS ARCTICUS*, MARSH.

This vegetation type occurs in stream flood-plains and along wet valley-bottoms. It covers approximately 3.5 percentage of the total area. The proportion of *Carex nebraskensis* is greater along streams where it forms dense swales 0.5 meters in height. *Juncus arcticus* dominates in slightly drier areas and forms taller, more open swales with a thick ground cover of litter through which small mammals tunnel. Another facies of this type is composed of *Typha latifolia* which forms small dense stands in very wet areas such as pond-margins (B).

Figure 11.

DRY, *POLYGONUM AVICULARE*--*AMBROSIA PSILOSTACHYA*, BARRENS. This vegetation unit is typically found on heavily bulldozed areas including fire breaks and old road beds. It comprises approximately 1.5 percentage of the total area. The plants are mainly decumbent annuals with the exception of *Ambrosia psilostachya* which often grows to 0.5 meters (B). The vegetation cover is very sparse and is a poor barrier to wind erosion.

Figure 12.

DRY, *HYPERICUM PERFORATUM*--*PARONYCHIA JAMESII*, PASTURE. This vegetation type covers much of the pediment that has been disturbed by over-grazing. It comprises approximately 11.5 percentage of the total area. Dominant and conspicuous herbs include *Hypericum perforatum*, *Paronychia jamesii*, *Eriogonum alatum* and *Liatris punctata*. The grasses are represented by *Koeleria macrantha* and *Buchloe dactyloides*.

Figure 13.

DRY, *HYPERICUM PERFORATUM*--*AMBROSIA PSILOSTACHYA*, BARRENS. This vegetation unit is found on heavily grazed pastures and mechanically disturbed roadsides. It covers approximately 3.3 percentage of the total area. The dominant herbs, including *Ambrosia psilostachya* (left, A), are weedy perennials. The grasses are mainly represented by a weedy annual, *Bromus tectorum* (B), and an indigenous perennial, *Bouteloua hirsuta*. The vegetation often averages 0.25 meters in height.

Figure 14.

DRY, *PINUS PONDEROSA*--*BROMUS TECTORUM*, SAVANNAH.

This vegetation type forms a stand of scattered trees on a dry, rocky, north-south ridge in the northwest corner of the area. It covers approximately 0.04 percentage of the total map area. *Pinus ponderosa* often grows to a height of 10 meters. Typical understory species are *Bromus tectorum* and *Rhus trilobata*. Many species of rock lichens are present, such as *Lecanora muralis* and *Acarospora fuscata*. *Pinus ponderosa* needles form a partial layer of litter over the soil surface; this may protect the soil from the wind erosion which is frequent in such an overgrazed area.

Figure 15.

DRY, *SECALE CEREALE*--*BROMUS TECTORUM*, FIELD.

This vegetation unit contains both planted and fallow fields and covers approximately 9.7 percentage of the total area. A typical field of *Secale cereale* has an understory of weedy annuals such as *Bromus tectorum* and *Lactuca serriola* (B). Harvesting results in a layer of litter over the soil surface which may protect it from wind erosion during the winter.

Figure 16.

MOIST, *CRATAEGUS ERYTHROPODA*--*GALIUM APARINE*, SCRUB. This vegetation type forms discrete stands on north-facing valley-sides and in gulches. It covers approximately 0.9 percentage of the total area. The dominant shrub species, *Crataegus erythropoda* often grows to two meters in height. Understory species include *Galium aparine*, *Bromus tectorum*, *Arctium minus* and *Hydrophyllum fendleri*. A shorter facies of this vegetation unit which is included in this type is often dominated by another shrub, *Rhus trilobata*.

vegetation left at Rocky Flats with which to compare and classify the many types of disturbed communities; 2) the purpose of the map is to show existing vegetation. Mueller-Dombois and Ellenberg (1974, p. 417) state that if the existing vegetation rather than the potential natural vegetation is mapped, the map will "form a documentation 'frozen' in time" and "may thus serve to evaluate successional changes." It is anticipated that the Rocky Flats maps will prove to be useful in this respect; 3) most of the plant community boundaries on which the Rocky Flats maps are based result from disturbance of the natural vegetation. An obvious example of this is where fence lines have prevented grazing from occurring on one side but not the other, resulting in a straight-line demarkation between two plant communities. An example of very sharp boundaries is where "managed" vegetation - called "replacement communities" (Mueller-Dombois and Ellenberg, 1974, p. 413) - has replaced the natural vegetation. The major replacement communities which are represented at Rocky Flats are agricultural fields which occur in the southeastern section of the overview map. Whittaker came to the following conclusion (in Poole 1974, p. 372): "Because of the tapered form of the population gradient, the composition of communities changes continuously along environmental gradients if the gradients are uninterrupted and communities undisturbed. Disruptions will tend to produce distinct community types or groups, in the same way that a cornfield is distinct from a neighboring pasture." Thus some of the problems inherent in drawing arbitrary boundaries around natural vegetation communities, and making vague subjective classifications have been alleviated at Rocky Flats.

A vegetation type is an abstract classification unit with many concrete members in the field. Vegetation mapping is not complete without gathering a data bank on the map units for the purpose of performing quantitative

analytical techniques. These analyses are able both to demonstrate the success of the mapping and to elucidate inter-relationships among the map units and the environmental factors. Each vegetation type has been characterized by standard quadrat methods. Percentage cover and frequency of component species and substrate characteristics (moisture, reaction, grain size, organic matter, carbonate content) were determined for each vegetation type. These data have been tabulated and are available on request. These data formed the basis of a phytosociological study which involved classification (clustering) techniques to examine the validity of the map units and which involved ordination (factor analysis) techniques to examine environmental controls. These phytosociological studies will be reported elsewhere.

Cartography:

The concern for cartography is becoming more prevalent in vegetation mapping. More ecologists are realizing that much of the time-consuming gathering of information can be wasted unless as much of the information as possible is presented in the form of a logically organized, useable map. Information which cannot be presented within the framework of a map can be included in a text which accompanies the map, but it should be kept in mind that not all of the map users will want to read it.

In addition to scale, there were basically three considerations in the drafting of the final version of the 1:12,000 map: colors, legend and base. Experts (for example, Kùchler, 1967, p. 107; Mueller-Dombois and Ellenberg, 1974, p. 423) suggest that vegetation map colors be chosen such that additional information about the map units (e.g. environmental conditions or density and height of the vegetation) can be presented through the use of a consistent meaningful color scheme. Two important factors, moisture and disturbance, were

considered in choosing the colors for the Rocky Flats map. The moisture factor was based partially on soil water absorption and partially on a visual estimate of moisture regime and colors were assigned as follows: orange = least moisture (dry), yellow = intermediate moisture (dry-moist), blue = most moisture (moist-wet). The disturbing factor was based primarily on percentage cover of bare soil and colors were assigned as follows: red = least disturbance, yellow = intermediate disturbance, grey = most disturbance. Table I shows how the two factors were combined to derive possible map colors.

Table I. Color for map vegetation units is derived from a consideration of moisture and disturbance regimes.

		MOISTURE →		
		Orange	Yellow	Blue
DISTURBANCE ↓	Red	Red-Orange	Orange	Purple
	Yellow	Yellow-Orange	Yellow	Green
	Grey	Brown	Tan	Blue-Grey

Since each factor was divided into three nominal groups, several map units could be closely related in both factors and could be represented by the same color. Where this occurred variation was achieved by using tints or shades of the color or by placing a pattern over the color. When more variation was required, an analogous color that would not otherwise be used was chosen. For example, five vegetation units had a low moisture rating (orange) and a high disturbance rating (grey) and could be represented by the color brown. A medium value of brown was chosen for one of the vegetation units, a pattern was placed over the same color to represent another vegetation

which was closely related to the first in terms of floristic composition but was more disturbed, and a shade of the color was used to represent a third vegetation unit. This exhausted the range of browns which could be distinguished easily on the map. An analogous color to orange, red, was chosen to represent the low moisture rating of the remaining two stands and combined with grey (high disturbance rating) to yield pink - a color which was not being used to represent any other vegetation units. The two vegetation units were closely related in terms of floristic content so the same color was used for both; a tint represented the more disturbed unit and a shade represented the less disturbed unit. In another case, only one vegetation unit had both a high moisture rating (blue) and a high disturbance rating (grey) and it is the only vegetation unit that is represented by the color blue-grey. One other consideration was made in choosing map colors; in general, map units which covered large areas were represented by light colors and those that covered small areas were represented by dark colors. This was done in order that the many small isolated areas would be clearly visible on the map.

Since the mapping was done on the basis of floristic composition, the map units could be described best by a floristic term. For consistency and definition, two species which were dominant in terms of cover and frequency in a representative sample of each vegetation type were chosen to represent that type in the map legend. In the case of a vegetation type that is characterized by a large number of species, the two dominant species might represent a small fraction of the total number of species. In the case of a vegetation type with a very small number of species, the two dominant species might represent a high percentage of the species in some areas. Also, (particularly for those vegetation types with two or more ecological facies, each of which is dominated by one plant species) the two species which are dominant in the

vegetation type as a whole and therefore appear together in the map legend may never occur together in the field.

To make the map more legible to non-botanists and to show relationships between units, a descriptive, physiognomic term was added for each vegetation type. Thus, two vegetation types labeled "pasture" are more similar physiognomically than one type labeled "prairie." One additional term: "dry," "moist," or "wet," is used in the map legend to describe the relative moisture content of the vegetation types. Table II provides the colored legend and gives both the colors and the names of the units which were mapped.

The 1:500 maps were easier to construct than the 1:12,000 map because they covered smaller areas (40 km^2 versus 0.1 km^2) and were not to be published in color. Color maps were considered unnecessary because the number of users would be small, because the cost of color printing are high, and because detail on the maps could be easily coded with commercially available black and white tones and hachurings. Patterns for coding the vegetation units were selected to reflect general soil moisture conditions; dark or dense patterns representing wet sites and light patterns representing dry sites. Simple "black-line ozalid" copies of the maps are provided with the report. For each study area two maps are provided; one of vegetation and the other of topography. At a future date these maps might be combined and printed in a more permanent fashion. Nomenclature of the map units correspond to that of the 1:12,000 map except for a few additional units.

Table II. Color legend for the 1:12,000 map of the greater Rocky Flats area.

WELL VEGETATED, LESS DISTURBED UNITS

DRY, <i>Buchloë dactyloides</i> — <i>Medicago sativa</i> , PASTURE
DRY, <i>Buchloë dactyloides</i> — <i>Arnica fulgens</i> , PASTURE
DRY, <i>Koeleria macrantha</i> — <i>Agropyron trachycaulum</i> , PRAIRIE
DRY, <i>Carduus nutans</i> — <i>Bromus tectorum</i> , BARRENS
DRY, <i>Stipa comata</i> — <i>Koeleria macrantha</i> , PRAIRIE
DRY, <i>Heterotheca villosa</i> — <i>Buchloë dactyloides</i> , PASTURE
MOIST, <i>Symphoricarpos occidentalis</i> — <i>Poa compressa</i> , LOW SCRUB
MOIST, <i>Agropyron trachycaulum</i> — <i>Poa compressa</i> , MEADOW
WET, <i>Salix exigua</i> — <i>Barbarea orthoceras</i> , STREAMBANK
WET, <i>Carex nebraskensis</i> — <i>Juncus arcticus</i> , MARSH

BARREN, DISTURBED, AND CULTIVATED UNITS

DRY, <i>Polygonum aviculare</i> — <i>Ambrosia psilostachya</i> , BARRENS
DRY, <i>Hypericum perforatum</i> — <i>Paronychia jamesii</i> , PASTURE
DRY, <i>Hypericum perforatum</i> — <i>Ambrosia psilostachya</i> , BARRENS
DRY, <i>Pinus ponderosa</i> — <i>Bromus tectorum</i> , SAVANNAH
DRY, <i>Secale cereale</i> — <i>Bromus tectorum</i> , FIELD
MOIST, <i>Crataegus erythropoda</i> — <i>Galium aparine</i> , SCRUB
CANAL, PONDS AND RESERVOIRS
PAVEMENT AND BUILDINGS

Literature cited:

- Caine, N. and P. Morin. 1975. The significance of frost action and surface soil characteristics to wind erosion at Rocky Flats, Colorado. Report No. COO-2517-1 to US ERDA under contract E(11-1)-2517.
- Küchler, A. W. 1967. Vegetation Mapping. Ronald Press, New York. 472 p.
- Mueller-Dombois, D. and H. Ellenberg. 1974. Aims and methods of vegetation ecology. John Wiley and Sons, New York. 547 p.
- Poole, R. W. 1974. An introduction to quantitative ecology. McGraw-Hill, New York. 532 p.
- Weber, W. A., G. Kunkel, and L. Shultz. 1974. A Botanical Inventory of the Rocky Flats AEC site. Report No. COO-2371-2 to US AEC under contract AT(11-1)-2371.
- Whicker, F. Ward. 1975. Radioecology of natural systems in Colorado. Report No. COO-1156-80 to US ERDA under contract AT(11-1)-1156.

List of Maps:

1. Location of the five 1:500 vegetation and 1-meter topographic maps.
2. 1:12,000 Color map of site and environs
3. 1:500 Topography and vegetation
Map A - CSU (Colorado State University) Macroplot 2 and surrounding area.
4. 1:500 Topography and vegetation
Map B - CSU (Colorado State University) Macroplot 1 and surrounding area.
5. 1:500 Topography and vegetation
Map C - Southeast corner of plant
6. 1:500 Topography and vegetation
Map D - CSU (Colorado State University) Macroplot NW and surrounding area.
7. 1:500 Topography and vegetation
Map E - CU (University of Colorado) Soil-frost effects and wind erosion study area.

VEGETATION ROCKY FLATS, COLORADO

N 39° 55'
W 105° 14' 15"

0 2000 4000 feet

WELL VEGETATED, LESS DISTURBED UNITS

- DRY, *Buchloë dactyloides*—*Medicago sativa*, PASTURE
- DRY, *Buchloë dactyloides*—*Arnica fulgens*, PASTURE
- DRY, *Koeleria macrantha*—*Agropyron trachycaulum*, PRAIRIE
- DRY, *Carduus nutans*—*Bromus tectorum*, BARRENS
- DRY, *Stipa comata*—*Koeleria macrantha*, PRAIRIE
- DRY, *Heterotheca villosa*—*Buchloë dactyloides*, PASTURE
- MOIST, *Symphoricarpos occidentalis*—*Poa compressa*, LOW SCRUB
- MOIST, *Agropyron trachycaulum*—*Poa compressa*, MEADOW
- WET, *Salix exigua*—*Barbarea orthoceras*, STREAMBANK
- WET, *Carex nebraskensis*—*Juncus arcticus*, MARSH

BARREN, DISTURBED, AND CULTIVATED UNITS

- DRY, *Polygonum aviculare*—*Ambrosia psilostachya*, BARRENS
- DRY, *Hypericum perforatum*—*Paronychia jamesii*, PASTURE
- DRY, *Hypericum perforatum*—*Ambrosia psilostachya*, BARRENS
- DRY, *Pinus ponderosa*—*Bromus tectorum*, SAVANNAH
- DRY, *Secale cereale*—*Bromus tectorum*, FIELD
- MOIST, *Crataegus erythropoda*—*Galium aparine*, SCRUB
- CANAL, PONDS AND RESERVOIRS
- PAVEMENT AND BUILDINGS

- PAVED ROAD
- UNPAVED ROAD
- RAILROAD
- CREEK OR DITCH WITH WATER
- CREEK OR DITCH WITHOUT WATER
- ELEVATION IN FEET

N 39° 51'
W 105° 10'

AREA A
SCALE: 1:480
CONTOUR INTERVAL: 1 METER

VEGETATION OF ROCKY FLATS, COLORADO

CSU macroplot 2 and surrounding area

feet
0 25 50 75 100
meters
0 10 20 30

GRAVEL ROADS AND NON-VEGETATED AREAS

WELL VEGETATED OR UNDISTURBED UNITS

DRY, *Heterotheca villosa*-*Schizachryium scoparium*, PRAIRIE

DRY, *Bromus japonicus*-*Carduus nutans*, BARRENS

MOIST, *Agropyron trachycaulum*-*Poa agassizensis*, MEADOW

MOIST, *Poa compressa*-*Bromus tectorum*, MEADOW

DRY, *Artemisia ludoviciana*-*Bromus tectorum*, MEADOW

DRY, *Bromus japonicus*-*Agropyron trachycaulum*, MEADOW

WET, *Juncus arcticus*-*Poa compressa*, MARSH

BARREN OR DISTURBED UNITS

DRY, *Bromus tectorum*-*Bromus japonicus*, BARRENS

VEGETATION OF ROCKY FLATS, COLORADO

CSU macroplot 1 and surrounding area

GRAVEL ROAD AND NON-VEGETATED AREAS

PAVED ROAD

WELL VEGETATED OR UNDISTURBED UNITS

DRY, *Heterotheca villosa*-*Schizachyrium scoparium*, PRAIRIE

DRY, *Bromus japonicus*-*Carduus nutans*, BARRENS

MOIST, *Cirsium arvense*-*Juncus arcticus*, MEADOW

MOIST, *Agropyron trachycaulum*-*Poa agassizensis*, MEADOW

MOIST, *Poa compressa*-*Bromus tectorum*, MEADOW

DRY, *Artemisia ludoviciana*-*Bromus tectorum*, MEADOW

DRY, *Bromus japonicus*-*Agropyron trachycaulum*, MEADOW

BARREN OR DISTURBED UNITS

DRY, *Convolvulus arvensis*-*Bromus tectorum*, BARRENS

AREA B
SCALE: 1:480
CONTOUR INTERVAL: 1 METER

VEGETATION OF ROCKY FLATS, COLORADO
Southeast corner of plant

BARREN OR DISTURBED UNITS

- DRY, *Bromus tectorum*-*Bromus japonicus*, BARRENS
- DRY, *Andropogon gerardii*-*Bromus tectorum*, BARRENS
- DRY, *Bromus tectorum*-*Salsola collina*, BARRENS
- DRY, *Agropyron cristatum*-*Alyssum minus*, BARRENS
- DRY, *Convolvulus arvensis*-*Bromus tectorum*, BARRENS

GRAVEL ROADS AND NON-VEGETATED AREAS

feet
0 25 50 75 100
meters
0 10 20 30

WELL VEGETATED OR UNDISTURBED UNITS

- DRY, *Heterotheca villosa*-*Schizachryium scoparium*, PRAIRIE
- DRY, *Bromus japonicus*-*Carduus nutans*, BARRENS
- MOIST, *Cirsium arvense*-*Juncus arcticus*, MEADOW
- MOIST, *Agropyron trachycaulum*-*Poa agassizensis*, MEADOW
- MOIST, *Bromus inermis*-*Poa compressa*, MEADOW
- WET, *Juncus arcticus*-*Poa compressa*, MARSH

INDIVIDUAL TREES OF *Ulmus pumila*

AREA C
SCALE: 1:480
CONTOUR INTERVAL: 1 METER

VEGETATION OF ROCKY FLATS, COLORADO

CSU macroplot NW and surrounding area

D

GRAVEL ROAD AND NON-VEGETATED AREAS

WELL VEGETATED OR UNDISTURBED UNITS

- DRY, *Heterotheca villosa*-*Schizachryium scoparium*, PRAIRIE
- DRY, *Bromus japonicus*-*Carduus nutans*, BARRENS
- MOIST, *Cirsium arvense*-*Juncus arcticus*, MEADOW
- MOIST, *Symphoricarpos occidentalis*-*Nepeta cataria*, LOW SCRUB
- MOIST, *Agropyron trachycaulum*-*Poa agassizensis*, MEADOW
- DRY, *Artemisia ludoviciana*-*Bromus tectorum*, MEADOW
- DRY, *Bromus japonicus*-*Agropyron trachycaulum*, MEADOW
- WET, *Typha latifolia*-*Carex nebraskensis*, MARSH

BARREN OR DISTURBED UNITS

- DRY, *Bromus tectorum*-*Bromus japonicus*, BARRENS
- DRY, *Pinus ponderosa*-*Prunus virginiana*, SAVANNAH
- MOIST, *Rhus trilobata*-*Bromus japonicus*, SCRUB

AREA D
SCALE: 1:480
CONTOUR INTERVAL: 1 METER

VEGETATION OF ROCKY FLATS, COLORADO CU soil-frost effects and wind erosion study area

5-2