
Chapter 4

Inventorying and Monitoring Grazing Land Resources

The section related to biomass estimation included here. For full reference see:
<http://www.glti.nrcs.usda.gov/technical/publications/nrph.html>

Chapter 4

Inventorizing and Monitoring Grazing Land Resources

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Chapter 4 includes:

- Procedures for vegetation inventory and monitoring on native grazing lands
- Procedures for evaluating and rating ecological sites
- Information on vegetation sampling techniques

The inventory and monitoring section describes methods of determining production, composition, and utilization. The evaluating and rating of ecological sites section gives procedures for determining trend and similarity index and evaluating rangeland health attributes on rangelands and forage value ratings on grazed forest lands. The *Sampling Vegetation Attributes*, Interagency Technical Reference, 1996, and *Utilization Studies and Residual Measurements*, Interagency Technical Reference, 1996, should be used for specific monitoring methods.

600.0400 General

Vegetation sampling is an important activity conducted by Natural Resources Conservation Service (NRCS) range management specialists and pasture management specialists. The data are used to develop inventories for planning, to monitor ecological change, to provide data to make management decisions, for the development of rangeland ecological site descriptions, for obtaining data for hydrologic models, for studies of treatment effects, and for many other purposes.

An inventory is defined as the collection, assemblage, interpretation, and analysis of natural resource data for planning or other purposes. Inventories are regularly completed to determine the present status of variables important to NRCS and decisionmakers. These inventories include physical structures, hydrologic features, rangeland ecological sites, animal resources, and other variables pertinent to the planning process. Biomass data collection, production, and composition by species are the standard techniques used by NRCS in characterizing rangeland ecological sites during the inventory process.

Several variables important to rangeland health and trend cannot be quantified using biomass data alone, so other techniques must be used to quantify characteristics of rangeland ecological sites. For instance, cover measurements can be used to quantify ground cover of litter, seedlings, microphytes (algae, lichen, and moss), and the condition of the soil surface. Cover is also important from a hydrologic perspective where the variables of interest might include basal cover of perennial and annual species, litter, coarse fragments, rills, and foliar and canopy cover above the soil surface.

Monitoring is used to quantify effects of management or environmental variation, at a location, through time. Monitoring can be short-term; for example, to quantify the amount of biomass used during a grazing event. It can also be long-term, such as to quantify trend in similarity index on a particular rangeland ecological site. Monitoring techniques are different from those used in inventory because monitoring uses the same location on a repetitive basis. Continued clipping at

the same location may eventually impact the productivity of the location, and biomass data collection is labor intensive and time consuming. Therefore, monitoring environmental change using another technique, such as cover, or a combination of techniques, such as cover and density, is often more efficient.

Data collections for ecological site descriptions are more involved than planning inventories. These data collections require collection of biomass and cover data as well as a review of local history related to the historic climax plant community. Data are also collected for use in hydrology assessments. Development of hydrologic models is an important activity in NRCS that requires data collection from a unique set of variables.

Studies of treatment effects are limited in NRCS. These studies involve intensive use of statistical methods and should be done in cooperation with USDA-Agricultural Research Service (ARS) or universities familiar with the particular type of study. Data collections for other purposes might include data for:

- Coordinating grazing history, stocking rate, and animal performance records in determining guides to initial stocking rates
- Preparing soil survey manuscripts and other publications
- Analyzing wildlife habitat values
- Planning watershed and river basin projects
- Assisting and training landowners and operators in monitoring vegetation trends and the impact of applied conservation practices and programs
- Exchanging information with research institutions and agencies
- Preparing guides and specifications for recreation developments, beautification, natural landscaping, roadside planting, and other developments or practices

600.0401 Inventory

All production and composition data collected by NRCS are to be based on weight measurements. Weight is the most meaningful expression of the productivity of a plant community or an individual species. It has a direct relationship to feed units for grazing animals that other measurements do not have.

Production is determined by measuring the annual aboveground growth of vegetation. Some aboveground growth is used by insects and rodents, or it disappears because of weathering before production measurements are made. Therefore, these determinations represent a productivity index. They are valuable for comparing the production of different rangeland ecological sites, plant species composition, and similarity index. Production data must be obtained at a time of year when measurements are valid for comparison with similar data from other years, other sites, and various conditions being evaluated.

Comprehensive interpretation of plant production and composition determinations requires that data be representative of all species having measurable production. Rangeland and other grazing lands may be used or have potential for use by livestock and wildlife, as recreation areas, as a source of certain wood products, for scenic viewing, and for other soil and water conservation purposes. The value of plant species for domestic livestock often is not the same as that for wildlife, recreation, beautification, and watershed protection. Furthermore, the principles and concepts of rangeland ecological site, similarity index, and other interpretations are based on the total plant community. Therefore, interpretations of a plant community are not limited solely to species that have value for domestic livestock.

The procedures and techniques discussed in this section relate primarily to rangeland. Most of them, however, also apply to grazeable forest and native or naturalized pasture. Changes or modifications in procedures required for land other than rangeland are described.

(a) Total annual production

The total production of all plant species of a plant community during a single year is designated **total annual production**. For specific purposes, production of certain plants or groups of plants can be identified as **herbage production** for herbaceous species, **woody-plant production** for woody plants, and **production of forage species** for plants grazed by livestock. Annual production, approximate production, total production, and production are used interchangeably with total annual production throughout this section.

Total annual production includes the aboveground parts of all plants produced during a single growth year, regardless of accessibility to grazing animals. An increase in the stem diameter of trees and shrubs, production from previous years, and underground growth are excluded.

(1) Total forage production

Total annual forage production is the annual production of plant species that are forage plants for the animals of concern. The same site may have different total annual forage production weights for cattle than that for deer. If total annual forage production is used as an inventoried item, then the animal of concern must be identified.

(2) Useable forage production

The useable forage production is that amount of total forage production to be allocated to or expected to be used by livestock or wildlife. When useable forage production is an inventoried item, the animal of concern and the desired use must be specified.

(b) Definition of production for various kinds of plants

(1) Herbaceous plants

These plants include grasses (except bamboos), grass-like plants, and forbs. Annual production includes all aboveground growth of leaves, stems, inflorescences, and fruits produced in a single year.

(2) Woody plants

(i) Deciduous trees, shrubs, half-shrubs, and woody vines—Annual production includes leaves, current twigs, inflorescences, vine elongation, and fruits produced in a single year.

(ii) Evergreen trees, shrubs, half-shrubs, and woody vines—Annual production includes current year leaves (or needles), current twigs, inflorescences, vine elongation, and fruits produced in a single year.

(iii) Yucca, agave, nolina, sotol, and saw palmetto—Annual production consists of new leaves, the amount of enlargement of old leaves, and fruiting stem and fruit produced in a single year. Until more specific data are available and if current growth is not readily distinguishable, consider current production as 15 percent of the total green-leaf weight plus the weight of current fruiting stems and fruit. Adjust this percentage in years of obviously high or low production.

(3) Cacti

(i) Pricklypear and other pad-forming cacti—Annual production consists of pads, fruit, and spines produced in a single year plus enlargement of old pads in that year. Until more specific data are available and if current growth is not readily distinguishable, consider current production as 10 percent of the total weight of pads plus current fruit production. Adjust this percentage for years of obviously high or low production.

(ii) Barrel-type cactus—Until specific data are available, consider annual production as 5 percent of the total weight of the plant, other than fruit, plus the weight of fruit produced in a single year.

(iii) Cholla-type cactus—Until specific data are available and if current growth is not readily distinguishable, consider annual production as 15 percent of the total weight of photosynthetically active tissue plus the weight of fruit produced in a single year.

(c) Methods of determining production and composition

Production and composition of a plant community are determined by estimating, by a combination of estimating and harvesting (double-sampling), or by harvesting. Some plants are on state lists of threatened, endangered, or otherwise protected species. Regulations concerning these species may conflict with harvesting procedures described. For example, barrel-type cactus in some states is a protected species, and harvesting is not allowed.

The weight of such plants is to be estimated unless special permission for harvesting can be obtained. Conservationists determining production should be aware of such plant lists and regulations. Environment Memorandum-1 (rev.) states NRCS policy on activities involving Federal- and state-designated threatened and endangered species.

(1) Estimating (by weight units)

The relationship of weight to volume is not constant; therefore, production and composition determinations are based on weight estimates, not on comparison of relative volumes. The weight unit method is an efficient means of estimating production and lends itself readily to self-training. This method is based on the following:

- A weight unit is established for each plant species occurring on the area being examined.
- A weight unit can consist of part of a plant, an entire plant, or a group of plants (see exhibit 4-1).
- The size and weight of a unit vary according to the kind of plant. For example, a unit of 5 to 10 grams is suitable for small grass or forb species. Weight units for large plants may be several pounds or kilograms.
- Other considerations include:
 - Length, width, thickness, and number of stems, and leaves
 - Ratio of leaves to stems
 - Growth form and relative compactness of species

The following procedure can be used to establish a weight unit for a species.

1. Decide on a weight unit (in pounds or grams) that is appropriate for the species.

2. Visually select part of a plant, an entire plant, or a group of plants that will most likely equal this weight.
3. Harvest and weigh the plant material to determine actual weight.
4. Repeat this process until the desired weight unit can be estimated with reasonable accuracy.
5. Maintain proficiency in estimating by periodically harvesting and weighing to check estimates of production.

The procedure for estimating production and composition of a single plot is:

1. Estimate production by counting the weight units of each species in the plot.
2. Convert weight units for each species to grams or pounds.
3. Harvest and weigh each species to check estimates of production.
4. Compute composition on the basis of actual weights to check composition estimates.
5. Repeat the process until proficiency in estimating is attained.
6. Periodically repeat the process to maintain proficiency in estimating.
7. Keep the harvested materials, when necessary, for air-drying and weighing to convert from field (green) weight to air-dry weight.

(2) Estimating and harvesting (double sampling)

The double-sampling method is to be used in making most production and composition determinations. The procedure is:

1. Select a study area consisting of one soil taxonomic unit. This should be a benchmark soil or taxonomic unit that is an important component of a rangeland ecological site or forest land ecological site.
2. Select plots to be examined at random.
3. The number of plots selected depends on the purpose for which the estimates are to be used, uniformity of the vegetation, and other factors. A minimum of 10 plots should be selected for all data to be used in determining rangeland ecological sites or other interpretive groupings and for data for use in the Ecological Site Information System. If vegetation distribution is very irregular and 10 plots will not give an adequate sampling, 20 plots can be selected. Fewer than 10

plots can be used if data are to be used for planning or application work with landowners, but the data should not be entered in the Ecological Site Information System

4. Adapt size and shape of plots to the kind of plant cover to be sampled. Plots can be circular, square, or rectangular. The area of a plot can be expressed in square feet, in acres, or in square meters.

If vegetation is relatively short and plot markers can be easily placed, 1.92-, 2.40-, 4.80-, and 9.60-square-foot plots are well suited to use in determining production in pounds per acre. The 9.6-square-foot plot is generally used in areas where vegetation density and production are relatively light. The smaller plots, especially the 1.92-square-foot plot, are satisfactory in areas of homogeneous, relatively dense vegetation like that occurring in meadows and throughout the plains and prairie regions. Plots larger than 9.6 square feet should be used where vegetation is very sparse and heterogeneous.

If the vegetation consists of trees or large shrubs, larger plots must be used. If the tree or shrub cover is uniform, a 66- by 66-foot plot of 0.1 acre is suitable. If vegetation is unevenly spaced, a more accurate sample can be obtained by using a 0.1-acre plot, 4,356 feet wide and 1,000 feet long. For statistical analyses, 10 plots of 0.01 acre are superior to a single 0.1 acre plot.

If vegetation is mixed, two sizes of plots generally are needed. A series of 10 square or rectangular plots of 0.01 acre and a smaller plot, such as the 9.6-square-foot plot nested in a designated corner of each larger plot, is suitable. The 0.01-acre plot is used for trees or large shrubs, and the smaller plot for lower growing plants. Weights of the vegetation from both plots are then converted to pounds per acre.

Plots with area expressed in square meters are used if production is to be determined in kilograms per hectare. If the plots are nested, production from both plots must be recorded in the same units of measure. For example, a plot 20 meters by 20 meters (or other dimensions that equal 400 meters) can be used for measuring the tree and shrub vegetation and a 1-meter plot

nested in a designated corner can be used for measuring the low-growing plants. Determine the production from both in grams and convert the grams to kilograms per hectare. Plots of 0.25, 1, 10, 100, and 400 square meters are commonly used.

After plots are selected, estimate and record the weight of each species in each plot using the weight-unit method. When estimating or harvesting plants, include all parts of plants whose stems originate in the plot, including all aboveground parts that extend beyond a plot boundary. Exclude all parts of herbaceous plants and shrubs whose stems originate outside a plot, even though their foliage may overlap into the plot.

After weights have been estimated on all plots, select the plots to be harvested. The plots selected should include all or most of the species in the estimated plots. If an important species occurs on some of the estimated plots, but not on the harvested plots, it can be clipped individually on one or more plots. The number of plots harvested depends on the number estimated. To adequately correct the estimates, research indicates at least one plot should be harvested for each seven estimated. At least 2 plots are to be harvested if 10 are estimated, and 3 are to be harvested if 20 are estimated.

Harvest, weigh, and record the weight of each species in the plots selected for harvesting. Harvest all herbaceous plants originating in the plot at ground level. Harvest all current leaf, twig, and fruit production of woody plants originating in the plots. If harvesting forage production only, then harvest to a height of 4.5 feet above the ground on forest land sites.

Correct estimated weights by dividing the harvested weight of each species by the estimated weight for the corresponding species on the harvested plots. This factor is used to correct the estimates for that species in each plot. A factor of more than 1.0 indicates that the estimate is too low. A factor lower than 1.0 indicates that the estimate is too high.

After plots are estimated and harvested and correction factors for estimates computed, air-dry percentages are determined by air-drying the harvested materials or by selecting the appropriate factor from an air-dry percentage table (see exhibit 4-2). Values for each species are then corrected to air-dry pounds per acre or kilograms per hectare for all plots. Average weight and percentage composition can then be computed for the sample area.

(3) Harvesting

This method is similar to the double-sampling method except that all plots are harvested. The double-sampling procedures for estimating weight by species and the subsequent correction of estimates do not apply. If the harvesting method is used, selection and harvest of plots and conversion of harvested weight to air-dry pounds per acre or kilograms per hectare are performed according to the procedures described for double sampling.

(4) Units of production and conversion factors

All production data are to be expressed as air-dry weight in pounds per acre (lb/acre) or in kilograms per hectare (kg/ha). The field weight must be converted to air-dry weight. This may require drying or the use of locally developed conversion tables.

(i) Converting weight to pounds per acre or kilograms per hectare—The weight of vegetation on plots measured in square feet or in acres can be estimated and harvested in grams or in pounds, but weight is generally expressed in grams. To convert grams per plot to pounds per acre, use the following conversions:

- 1.92 ft² plots—multiply grams by 50
- 2.40 ft² plots—multiply grams by 40
- 4.80 ft² plots—multiply grams by 20
- 9.60 ft² plots—multiply grams by 10
- 96.0 ft² plots—multiply grams by 1

In the metric system, a square-meter plot (or multiple thereof) is used. Weight on these plots is estimated or harvested in grams and converted to kilograms per hectare. A hectare equals 10,000 square meters. A kilogram equals 1,000 grams. To convert grams per plot to kilograms per hectare, use the following conversions:

- 0.25 m² plots—multiply grams by 40
- 1 m² plots—multiply grams by 10
- 10 m² plots—multiply grams by 1
- 100 m² plots—multiply grams by 0.10
- 400 m² plots—multiply grams by 0.025

When assisting landowners and operators in determining approximate production, express data in pounds per acre. Use the following factors to convert from one system to another:

To convert	To	Multiply by
Metric units:		
Kilograms per hectare	Pounds per acre	0.891
Kilograms	Pounds	2.2046
Hectares	Acres	2.471
English units:		
Pounds per acre	Kilograms per hectare	1.12
Pounds	Kilograms	0.4536
Acres	Hectares	0.4047

(ii) Converting green weight to air-dry weight—If exact production figures are needed or if air-dry weight percentage figures have not been previously determined and included in tables, retain and dry enough samples or harvested material to determine air-dry weight percentages. The percentage of total weight that is air-dry weight for various types of plants at different stages of growth is provided in exhibit 4-2. These percentages are based on currently available data and are intended for interim use. As additional data from research and field evaluations become available, these figures will be revised. Air-dry weight percentages listed in the exhibit can be used for other species having growth characteristics similar to those of the species listed in the exhibit. States that have prepared their own tables of air-dry percentages on the basis of actual field experience can substitute them for the tables in exhibit 4-2. Local conservationists are encouraged to develop these tables for local conditions and species. Some interpolation must be done in the field to determine air-dry percentages for growth stages other than those listed.

The relationship of green weight of air-dry weight varies according to such factors as exposure, amount of shading, time since last rain, and unseasonable dry periods. Several samples of plant material should be harvested and air-dried each season to verify the factors shown or to establish factors for local use.

(d) Methods for determining production and composition for specific situations

The intended use of the data being collected determines the method, or variation thereof, that is selected. Unless specifically stated otherwise, composition is always determined by computing the percent from the weight, either estimated or weighed. Several activities require knowledge of production, but in varying degrees of detail. The methods or variations that apply to several of these situations are described in this section.

(1) Collecting production and composition data for documentation

Data to be used for preparing rangeland ecological site descriptions grouping soils into rangeland ecological sites, and other guides, and processing in the Ecological Site Information System are to be obtained by the double-sampling procedure. All documentary production and composition data are to be recorded on form NRCS-RANGE-417. Production determinations are made as follows:

- Tabulate production data by estimating and harvesting plots of the potential plant community for one or more soil taxonomic units associated with the site or group.
- Obtain production data from vegetation that has not been grazed since the beginning of the current growing season.
- Make determinations near or shortly after the end of the growing season of the major species. Give due consideration to species that mature early in the growing season. If plant communities consist of a mixture of warm- and cool-season species, at least two determinations may be needed during a single production year. The following procedure should then be used:
 - Select two periods that will yield the best estimate of the growth of most of the important species.

- At the first determination, estimate and harvest only the species that are mature or nearly mature.
- At the second determination, select a new set of plots for estimating and harvesting all other species, but record the data on the same form NRCS-RANGE-417 used for the first determination.
- At the second determination, harvest the plots having numbers corresponding to those harvested at the first determination. For example, if plots number two and four were harvested the first time, plots number two and four are harvested the second time. Correction of sampling errors as well as moisture data can then be made. Any species not included in these plots can be harvested individually.
- If two determinations are made, record the date of the second determination in the Remarks space of form NRCS-RANGE-417.
- Repeat production determinations in different years to reflect year-to-year variations.
- Analyze production data from soil taxonomic units to determine the soils that should be tentatively grouped into specific rangeland ecological sites or other interpretive groupings and also to obtain data for inclusion in published soil surveys. Soils are not grouped based on production alone. The species composition by weight is also used.

The procedures discussed above are also to be used in obtaining data for the various status ratings for rangeland ecological sites and for different forage value ratings on those sites. To accomplish this, collect data from areas that represent specific similarity index or forage value ratings for the rangeland ecological site in a single production year. This procedure will be used for all kinds and uses of grazing lands.

(2) Estimating production and composition of an area

Use the following procedure to estimate similarity index of a rangeland ecological site, areas of different similarity indices within a rangeland ecological site, and forage value rating of a forestland ecological site or a native pasture group:

- Estimate production, in pounds per acre or kilograms per hectare, of individual species in the area.

- Compute composition, by weight, of the area from estimated production data. Sample the production on a series of random plots.
- Compute average production of the plots in terms of pounds per acre or kilograms per hectare, to further check these estimates for the area as a whole, harvest or double sample.
- Using these average figures, compute average composition. Although by using this procedure some species of minor importance may be missed, the procedure provides a useful check on estimates.
- Repeat this procedure until proficiency is attained. To gain proficiency, double sample within a range of similarity indices in several rangeland ecological sites each year.

(3) Inventorying composition for conservation planning

During conservation planning, it is often necessary to determine plant composition when plant growth is not ideal for making such determinations. Some grazing units are grazed at the time of planning. In places, estimates must be made at different stages of plant growth or when plant vigor varies from grazing unit to grazing unit. In some years production is obviously much higher or much lower than normal because of weather extremes. In making production estimates, therefore, it is often necessary to mentally reconstruct plant growth as it would most likely appear if undisturbed at the end of an average growing season. Adjustments or reconstruction must be made for percent of growth made during the year, percent of growth grazed or otherwise lost, and for air dry percentages.

(4) Determining production of tree or large shrub vegetation on rangeland

Rangeland ecological site descriptions are to include composition, by weight, of trees that are part of the climax plant community. Determining production of trees and large shrubs by harvesting portions of stands is time consuming and impractical for regular field conservation planning procedures. Research scientists are devising methods for calculating current production of some species on the basis of measurements of such factors as crown width or height and basal area. These data are to be used in estimating the annual production of trees and large shrubs.

Range management specialists, pasture specialists, and foresters work together to prepare production guides for various kinds of understory and tree stands for use by field office personnel. Range management specialists are to use the following procedures in preparing guides for rangeland:

1. Select a few sample trees for each species. Samples should reflect variations in tree size, form, and spacing.
2. Determine current production of sample trees.
3. Determine production through a combination of estimating and harvesting. For estimates, establish appropriate weight units. These units can be an entire small tree or a branch or cluster of branches from large trees (see exhibit 4-1). Determinations from sample trees should include all components of current production except bark and wood of other than current twigs. Current leaf and twig production can be easily identified for some species. For these species, current leaf growth can be collected. Field determinations of production can be based on current leaf production only if data are available to indicate the percentage that various components contribute to total production. For example, Utah research shows that current production of balsam fir and Utah juniper is about 30 percent of the total foliage. Current production of these two species can be calculated by determining the total foliage present, then multiplying by 0.30 and adding to this figure the current fruit (cone) production. For species requiring 2 years for fruit maturity, half the weight of mature fruit represents the current production of fruit.
4. Expand estimates to plots 0.1 acre or larger. Record production for each tree or large shrub. If the 0.1- or 0.01-acre or the 400-square-meter plots are used in stands of trees, the likelihood of the plot boundary hitting the bole of a tree is high. If this happens exclude the first hit tree and include the second hit and so on or vice versa. Also describe the appearance and aspect of the plot. List component species, tree size, growth forms, number of trees, and density of the canopy.
5. Repeat this process for stands of various kinds of trees or large shrubs. On the basis of data thus collected, prepare guides that list the approximate annual production of stands of various kinds of trees or large shrubs (see exhibit 4-4).