Planned comparison protocol:

Directed natural regeneration and fodder enrichment in communal grazing exclosure

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1. Research summary

Question or objectives	How can exclosure forage and fodder productivity for different livestock feeding needs be cost-effectively improved, and how does improvement vary with context?
Hypothesis	Removing unproductive or undesirable forage and fodder species and plant parts, with gap-planting of local forages generates more biomass, of higher quality, and better suited to farmer livestock feeding preferences, than does undirected regeneration, relative to management costs. Plowing and planting of improved forages produces the highest yield and quality of forage.
Options to compare	Directed (removal of unproductive/undesirable species/plant parts) vs. undirected regeneration
	Directed regeneration (removal of unproductive/undesirable species/plant parts) with vs. without gap-planting of local forages
	Plowing and planting of 2 improved forage species
Contexts to compare	Elevation
	Dominant soil types x Slope classes
	Market access (distance as proxy)
	Exclosure productivity (total $t\ yr^{-1}$)
Study units	30 exclosures, each with 1–2 plots, and 4 nested treatment sub-plots per plot. Exclosures > mean area (18.8 ha ± 17.6 SD) have 2 plots.
Responses to measure	Grass basal area, aboveground biomass of species preferred and unpreferred for cut-and-carry, forage quality (CP, IVOMD), labor cost, input cost (seeds and rhizomes), farmer preference for each option
Roles of farmers	• Comment on the treatments of the PCs so as to decide what is relevant for the area • Implementing the PCs according to the agreed treatment combination • Keeping records ('Farmer Researchers') and experience sharing. A data capture sheet will be prepared to specify what to record, when and how. If there is no person in the household who can do this, the program will arrange to support the data recording. • Participate in the evaluation of options at the mid and end of the production cycle or agreed time period
Roles of others	**ILRI:** • Lead in the preparation of the planned comparison protocol and roll out • Provide technical backstopping in the delivery of the

	training of extension program staff, workers and farmers • Lead the preparation of the data capture format, analysis and reporting **CBINReMP:** • Provide budget for labor and propagation materials • Contribute to the design of the planned comparisons • Lead the organization and delivery of training of program staff extension workers and farmers • Lead the identification of farmers who would like to be involved in the planned comparison • Organize exchange visits • Participate in the evaluation of the options **Farmer Researchers and Development Agents in the respective *kebeles:*** • In collaboration with CBINReMP identify farmers who would like to engage in planned comparisons • Participate in training of farmers • Provide technical support • Follow up on implementation of PCs and data recording • Assist implementation and data recording
Study/experimental design	Among/within (nested) exclosure trial
Suggested timing (start and end)	Study initiation and plot establishment, December 2016; First survey, May 2017; Treatment of plots, June 2017; Outcome assessment, September–October 2017

2. Research process

Location criteria

The Community-Based Natural Resources Management Project (CBINReMP), implemented by the regional Amhara Bureau of Agriculture and Rural Development, has identified woredas where the research is strongly relevant and reasonably feasible. The specific kebeles and micro-watersheds (MWS) are selected to capture key contextual variation, notably environmental variation associated with elevation, and social differences associated with market access, in a factorial manner to the greatest extent permitted by landscape configuration.

Setting up community research oversight and liaison

The contribution of communities to the research is essential to its success. Here, representatives from the community are intended to play several roles: contributing to the design of the research, sharing local knowledge on exclosure resources and their use, maintaining the research plots, assisting with monitoring, and assessing the treatment effects. For these reasons, care is required during the initial set-up of the research, to ensure clarity, obtain substantive community input, and resolve any concerns.

In the first meeting with each community, a general consensus among community members, project representatives, and researchers must be forged for the research to proceed. In addition to the researchers and project research focal point, the following must be

present: representatives (or the entirety) of the exclosure users' group (EUG), representatives (or the entirety) of the community watershed team (CWT), and the woreda focal person (WFP) for the project. Kebele representatives (e.g., kebele leader) are not required, but should be invited. First, a short presentation is made, describing the goals of the research. A discussion follows in which general comments are invited, including possible changes to the research.

The bulk of the discussion relates to the general goals of the community in managing their exclosures, including feeds, seasons, species, and production purposes. Once the general uses of exclosures are clear, a preliminary discussion is conducted on what undesirable or unproductive species and plant parts may be beneficial to remove. While the final treatments (on the removal of species and plant parts) will be partly determined by the composition of each plot, and will sometimes be plot-specific, this preliminary discussion is an opportunity for the larger community to register their preferences and views. To the extent possible, this meeting may create general rules for the removal of specific species, plant functional types (or growth forms), and/or plant parts. All meeting participants are then invited to join the team during plot establishment and treatment application. Before the meeting is concluded, check that all individuals with responsibility for exclosure management have had their names and contact information recorded, and mention that we are recruiting one Farmer Researcher (FR) for each exclosure, who resides close to the exclosure.

Measuring outcomes, impacts, and feed use patterns

A survey instrument has been prepared to track the outcomes (change in the production of forage/fodder from the exclosure, milk, and traction power and their farm-gate economic value) and impacts (indicators of income and nutritional intake change) of the research. In addition, a portion of the survey will be fielded at least semi-annually (quarterly if feasible) to track seasonal use of various feeds. Information on feed use patterns will increase the precision of recommendations made to communities, and clarify the implications of the research findings for different, yet similar, contexts. A summary of the indicators to be surveyed is provided at the end of this document.

Establishing plots and applying treatments

Each exclosure under study is represented by 1–2 plots. Exclosures larger than the mean size (currently estimated at ~15 ha, subject to downward revision with more detailed measurements) have 2 plots. Plot locations are determined with random numbers, although may be moved if necessary. Plots may not be placed under large shrubs or trees (> 25% woody cover or trees > 3 m high), in gullies, < 25 m from the edge of the exclosure, or in areas where > 50% of vegetation would be removed.

Each plot contains 5 treatments: (i) weeding treatment (W): removal of undesirable or unproductive species and plant parts only (for herbaceous plants, removal means complete uprooting); (ii) weeding/re-planting treatment (WR): undesirable or unproductive species and plant parts with subsequent gap-planting of supplementary species; (iii) *Pennisetum pedicellatum* treatment (PP): plowing and planting of *Pennisetum pedicellatum* (desho grass) rhizomes at 20x30 cm spacing; (iv) *Chloris gayana* treatment (CG): plowing and planting of *Chloris gayana* (Rhodes grass) seeds at 18.5 kg/ha seeding rate; and (v) control: typical management (usually all aboveground grass biomass is cut, and no or few woody species and weeds cut).

A subset of volunteer stakeholders representative of community institutions as well as the WFP and FR oversee field application of treatments. Treatments are applied in each plot firstly according to rules as agreed in community meetings. Where necessary due to species composition (e.g., a toxic species not previously discussed), additional decisions on removals may be made. For all plots within an individual exclosure, treatments must be uniform and

consistent, within the limits of natural variation. Note two general rules affecting removals: (1) trees and shrubs > 2.5 cm basal diameter, or > 1 m high, may not be removed; (2) if > 50% of plot vegetation cover must be removed, the plot must be moved.

A training is held to standardize treatments among sites. Following the training, plowing of the *Pennisetum pedicellatum* (PP) and *Chloris gayana* (CG) treatments comes first, after some rain but before the rains begin in earnest, around May for the area. Next, the PP and CG treatments are planted. Finally, the weeding (W) and weeding/re-planting (WR) treatments are conducted. Since treatment application will vary slightly from site-to-site, the cover, biomass, and species removed, and the species replanted, are recorded using the treatment recording datasheet (see appendices). Following treatment establishment, the primary responsibility for maintaining the treatment plots falls upon the Farmer Researcher (FR), with support from the woreda focal person (WFP) of the project by means of visits twice per month.

3. Field measurement details

Equipment

1. Camera
2. GPS
3. Field balance
4. Wooden pole marked at 1 and 2 m
5. Clippers
6. Paper bags for forage tissue samples
7. Plastic bags for soil samples
8. Bulk density cores
9. Data collection sheets (provided in appendices)

Measurements

1. Exclosure description (baseline)
2. Sample soils (baseline)
3. Area and height (baseline, outcome)
4. Forage tissue samples (outcome)
5. Record treatments
6. Harvest biomass (outcome) and retain sample
7. Trees and shrubs (baseline, outcome)

1. Exclosure description. Place 2 m pole in the plot center point, stand downhill 4 m (from the center point), center the camera on the middle (1 m high) of the pole, and take 2 photos below each treatment. Use a GPS to record the position of the plot center.

2. Soils. Use bulk density cores to remove samples from the eight specified locations. Combine the two sub-samples for each control, and for the weeding (W) and weeding/re-planting (WR) treatment sub-plots. Retain samples in a plastic bag.

3. Area and height. For herbaceous plants, score % area, mean canopy (leaf) height for species both preferred and unpreferred for cut-and-carry, and mean half-canopy height for preferred species only. For woody plants < 2.5 cm basal diameter < 1 m high, score % area and mean height. Next, look under the grass canopy and record grass basal area. Record any area not covered (by vegetation, litter, or rocks) as bare soil (look upward if necessary).

4. Forage tissue samples. At 3 regular points in each 1 m^2 sampling plot, harvest from the herbaceous layer (all herbaceous plants, and all woody plants < 2.5 cm basal diameter or < 1 m high) whole stems (or ramets). These stems are representative of the 2–3 genets rooted closest to the 3 sample points, and in proportion to their biomass. Remove the stems or ramets from 5 cm aboveground, avoiding grass root crowns. Record the approximate % of tissue sample biomass comprised by dominant species (> 30% of sample biomass) and a species name or code. If the sample contains any species that are not fed to livestock, or that livestock will not eat, remove them from the sample. Indicate whether the sample contains traces of forbs or woody species. Do not combine the samples for each control and each treatment into a single bag, keep all samples separated. If necessary, repeat harvest in equal proportions until 20 g estimated dry weight is attained (~40-50 g wet weight).

5. Record treatments. First, stand in the four corners of the weeding (W) and weeding/re-planting treatment (WR) sub-plots, and record the approximate % of area where the soil was disturbed during weeding. For species and biomass removed in treatments, record the

approximate % of biomass removed comprised by the primary species removed (the top 5 species removed), a species name or code (Amharic at least). Finally, record the number of person-hours taken for application of the treatments, and the local species used for re-planting in the WR treatment.

6. Harvest biomass (and retain sample). As per typical management, harvest the entire 1 m^2 sampling plots 1–4 from 5 cm aboveground, avoiding root crowns of grasses, and take wet weight. Retain and dry the sample from sampling plot 4 in each weeding treatment and the controls. For the PP and CG planted treatments, where plots 2 and 4 are harvested and retained for drying.

7. Trees and shrubs. For any trees and shrubs > 2.5 cm diameter or > 1 m high, and inside the larger 56 x 15 m plot, record height and canopy length and width, indicating trees over the 1 m^2 plots separately from those not over the 1 m^2 plots.

4. Focus group discussions and key informant interviews

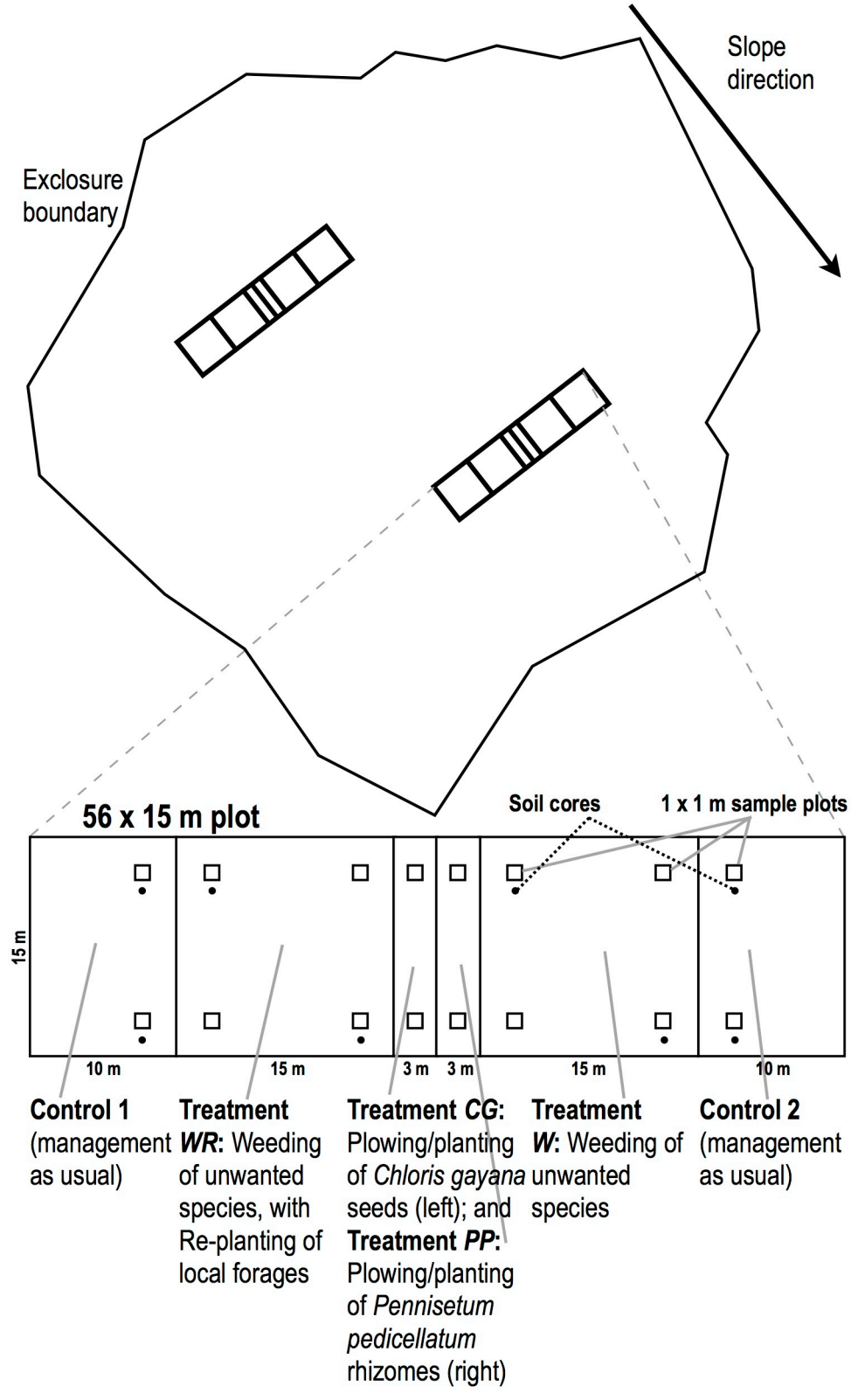
After field application of treatments is complete, hold a focus group discussion with those farmers who joined the field work, and any farmers from the introductory meeting who wish to join the discussion.

Make 2 lists for the species in the exclosure that were retained after treatment (dominants, >30% of biomass), and the primary species removed (>30% of biomass removed) during treatment application. Then use the questions in Appendix A to record why species were retained, or removed.

For species retained after treatment application, record preference, primary and secondary uses, primary and secondary seasons of use, and propagation potential. For species removed during treatment, record preference, and the reason(s) for removal.

Before closing the meeting, identify possible key informants willing to conduct more extensive semi-structured interviews. Promote the appointment of Farmer Researchers (FRs) who will assist study implementation and data collection.

Plot design and layout



Exclosure description

Exclosure name _____ Plot _____ Date _____
Woreda _____ Kebele _____ Watershed _____
Latitude _____ Longitude _____ GPS Waypt _____ Photos _____

Vegetation and bare soil cover	Herbaceous cover	%: None — 0-3% — 4-15 — 16-40 — 41-65 — >65 Mean height (cm):_____
	Tree and shrub cover (%) and mean height (m)	%: None — 0-3% — 4-15 — 16-40 — 41-65 — >65 Mean height (cm):_____
	Bare soil cover (%) (not covered by vegetation or rocks)	%: None — 0-3% — 4-15 — 16-40 — 41-65 — >65
	Rock/stone cover (%)	%: None — 0-3% — 4-15 — 16-40 — 41-65 — >65
Soils	Color and type	0-20 cm: Below 20 cm:
	Texture	0-20 cm: Below 20 cm:
	Erosion prevalence (circle all that apply)	Rill — Gully — Sheet — Pedestal — Soil deposition
Topography	Slope	String *length in m* to level string at 50 cm: _____ Percent slope: _____
	Position	Bottomland — Footslope — Midslope — Upland
Management evidence	Grazing:	%: None — 0-3% — 4-15 — 16-40 — 41-65 — >65
	Cutting of grass:	%: None — 0-3% — 4-15 — 16-40 — 41-65 — >65
Notes		

Exclosure _____ Plot _____ Treatment _____ Date _____

		Sub-plot:	**1**		**2**		**3**		**4**	
		Sub-plot notes:								
		Herbaceous type:	Pref	Non-pref	Pref	Non-pref	Pref	Non-pref	Pref	Non-pref
Herbaceous		Cover (%)								
		Canopy height (cm)								
		½–Canopy height (cm) (preferred only)								
Woody (< 2.5 cm basal diameter (BD) or < 1 m high)		Cover (%)								
		Canopy height (cm)								
Grass basal area		Cover (%)								
Bare soil		Cover (%)								
Trees/ shrubs (> 2.5 cm BD or > 1 m high)	Over the 1m^2 plots	Ht / Wd / Lg (m)								
	Not over the 1m^2 plots	Ht / Wd / Lg (m)								

Exclosure _____ Plot _____ Treatment _____ Date _____

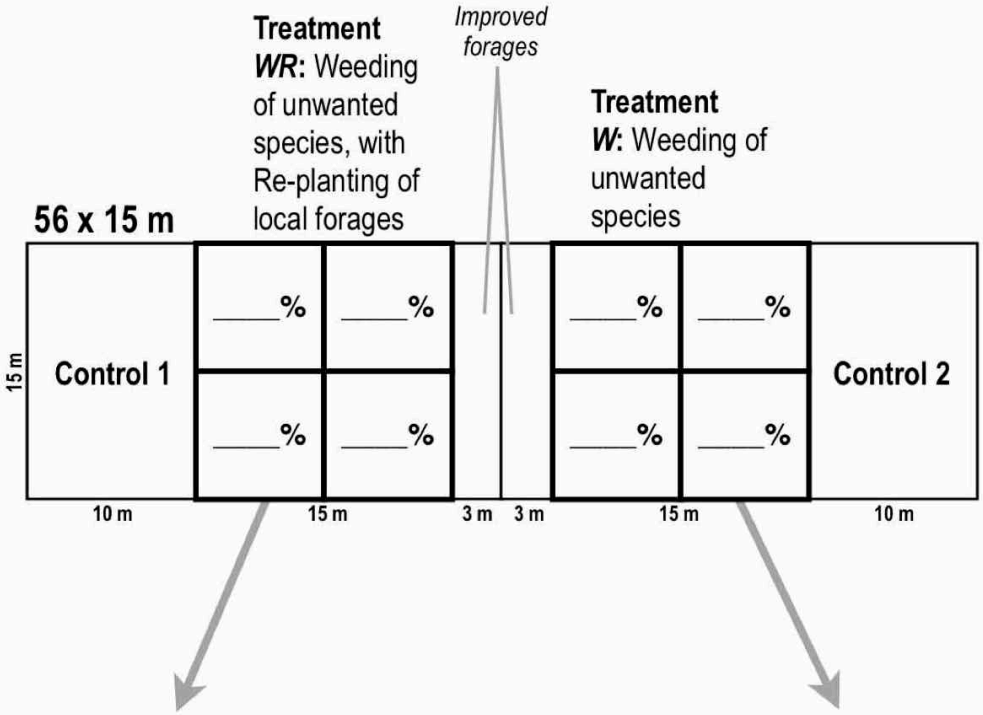
		Sub-plot:	**1**		**2**		**3**		**4**	
		Sub-plot notes:								
		Herbaceous type:	Pref	Non-pref	Pref	Non-pref	Pref	Non-pref	Pref	Non-pref
Herbaceous		Cover (%)								
		Canopy height (cm)								
		½–Canopy height (cm) (preferred only)								
Woody (< 2.5 cm basal diameter (BD) or < 1 m high)		Cover (%)								
		Canopy height (cm)								
Grass basal area		Cover (%)								
Bare soil		Cover (%)								
Trees/ shrubs (> 2.5 cm BD or > 1 m high)	Over the 1m^2 plots	Ht / Wd / Lg (m)								
	Not over the 1m^2 plots	Ht / Wd / Lg (m)								

Exclosure _____ Plot _____ Treatment _____ Date _____

		Sub-plot:	1		2		3		4	
		Sub-plot notes:								
		Herbaceous type:	Pref	Non-pref	Pref	Non-pref	Pref	Non-pref	Pref	Non-pref
Herbaceous		Cover (%)								
		Can. height (m)								
		½–Canopy height (cm) (preferred only)								
Woody (< 2.5 cm basal diameter (BD) or < 1 m high)		Cover (%)								
		Can. height (m)								
Grass basal area		Cover (%)								
Bare soil		Cover (%)								
Forage samples		Name and % of sample								
		Name and % of sample								
		Name and % of sample								
		Legume–Forb–Woody present	L — F — W		L — F — W		L — F — W		L — F — W	
Harvest		Wet weight (g)								
		Dry weight (g)								
Trees/ shrubs (> 2.5 cm BD or > 1 m high)	Over the 1m^2 plots	Ht / Wd / Lg (m)								
	Not over the 1m^2 plots	Ht / Wd / Lg (m)								

Exclosure name _____ **Plot** _____ **Date** _____
Woreda _____ Kebele _____ Watershed _____

STEP 1. Record what % area was weeded, in all 4 quadrants of the weeding treatments.



STEP 2. Record the top 5 species of weeds removed, and the approximate % of the total biomass removed for the top 5 species.

Weeding + Re-planting (WR)

Rank (1=high-est)	Species (Amharic name)	Species (Scientific name)	% of weed biomass removed
1			
2			
3			
4			
5			

Weeding only (W)

Rank (1=high-est)	Species (Amharic name)	Species (Scientific name)	% of weed biomass removed
1			
2			
3			
4			
5			

STEP 3. Record the time for treatments.

Weeding + Re-planting (WR)

Task	Number of people	Number of hours	Number of people-hours (People x Hours)
Weeding			
Collecting grass rhizomes			
Planting grass rhizomes			

Weeding only (W)

Task	Number of people	Number of hours	Number of people-hours (People x Hours)
Weeding			

STEP 4. Record the species planted in the *WR* treatment.

Species 1. Amharic name _____ Scientific name _____ % _____
Species 2. Amharic name _____ Scientific name _____ % _____
Species 3. Amharic name _____ Scientific name _____ % _____

Summary of survey instrument: Indicators for outcomes, impacts, and feed use patterns

	Indicator	Measure	Frequency
Outcomes	Forage production and economic value	Forage biomass cut from the exclosure (# of 100 kg bags in the past 6 mo); Value of 1 100 kg bag (ETB)	Annual
	Milk production and economic value	Milk produced (average L/day) in the past 6 months; Value of 1 L (ETB)	Annual
	Traction power and economic value	Household plowing ability (ha/day); Value of 1 ha plowing (ETB)	Annual
Impacts	Forage/fodder-based income	Income from sale of forage/fodder from the exclosure in the past 6 months (ETB)	Annual
	Milk-based income	Income from sale of milk in the past 6 months (ETB)	Annual
	Traction-based income	Income from renting of draught animals in the past 6 months (ETB)	Annual
	Animal sale-based income	Income from sale of animals in the past 6 months (ETB)	Annual
	Nutrition	Milk consumption (average L/day) in the past 6 months	Annual
Feed use pattern	Type, source, and amount of feeds used	% of main feed sources used, including grass and hay from inside vs. outside exclosure	Semi-annual to quarterly
	Utilization of feeds	% of main feed sources used by animal type	Semi-annual to quarterly
	Changes in feed use	Increasing, decreasing, or constant over the past 3 years	Semi-annual to quarterly
	Reasons for change in feed use	List of drivers for change in feed use	Once