Instructions to Fill out CPS 340 Cover Crop Implementation Requirements:

- Seeding Plan: Fill out detailed information for all sections in the Seeding Plan. This should be detailed enough that the producer can complete the Cover Crop planting according to the instructions in the Seeding Plan.
    - Timing: Between crops, prior to CPS 512 planting, etc.
    - Site Preparation: Be specific about equipment and timing
    - Fertilization: Compost, conventional fertilizer, fish emulsion, etc.
    - Rhizobium: Appropriate rhizobium MUST be utilized with legumes (if not already in the soil, most aren't). Legumes may be coated or rhizobium may be purchased for application to seed prior to seeding.
    - Seeding date: Be specific, make sure aligns with climatic conditions, cash crop requirements, etc.
    - Seeding depth: Pay attention to seed size and the recommended seeding depth for different species. This may require multiple hoppers on a drill or require multiple passes. May need filler material for certain seeds.
    - Seeding method: Be specific about the equipment and method specific in your drop down from the calculator (No till drill, broadcast with a spinner spreader)
    - Precipitation/Irrigation: Will depend on climatic conditions.
    - Termination date: Be specific, make sure aligns with climatic conditions, cash crop requirements, crop insurance requirements, stage of growth of cover crop, prior to seedheads, at milk stage, at 30% anthesis, etc.
    - Termination Method: Be specific about equipment, size, methods, chemicals, etc.
    - Backup Termination Method: ALWAYS have a backup and make sure the producer is aware.
    - Management considerations: Residue, weed pressure, pest pressure, what happens if the stand doesn't establish well, etc.
    - Additional requirements: Soil temperature requirements for warm season and cold season cover crops is an important factor when planning cover crops.
- Planned Cover Crop Mixture: The planner will utilize the WA Cover Crop Calculator to design a cover crop seeding rate for either a single species or a mixture of cover crop species. The planner may copy information from the calculator into the Implementation Requirements, or they may insert a PDF of the calculator mix into the Implementation Requirements. All seeding information shall be based on the WA Cover Crop Calculator information.
    - Contingency plan: What producer will do if planned species are not available, if drought occurs, etc.
- Practice Purpose: Any selected Cover Crop purpose chosen shall be integrated into the mix and/or seeding plan.
- RUSLE/WEPS Information: If required by the practice purpose, include the Erosion Rates and Soil Condition Index in the Planner Document.
- Benchmark: Include ALL information.
- As Built:
    - Seeding Implementation (page 7 of 9): For certification planner must fill out all information as provided by producer and as seen in the field.

  - Certification using the Cover Crop Calculator: Planner must input all information into the Certification tab of the WA Cover Crop Calculator to find whether the minimum seeds per square foot was met and may or may not be certified. Planner may copy all information from WA Cover Crop Calculator into the As Built or the planner may insert a PDF of the certification tab of the WA Cover Crop Calculator into page 8 of 9 of the Implementation Requirements.
  - Planner must include photos of seed tags and of the cover crop in the field with notes.
- Only pages 1-4 shall be provided to the producer (unless all pages of IR are requested). Pages 5-9 do not need to be included in documents given to the producer.
- Pages 1-6 shall be filled out, signed, and included in the case file prior to producer signing the contract. Pages 7-9 do not need to be filled out prior to contract signing.
- Pages 7-9 shall be utilized during certification as the As Built document.

General:

- Cover crop: Grown not for harvest, to provide another benefit. General term.
- Green manure: type of cover crop that is incorporated into soil via tillage to boost organic matter and release nutrients.
- 1% soil organic matter = 10 lbs. Nitrogen available to next crop during next growing season
- Couple with legume from prior season cover crop, probably meet/exceed next crop's N need
- 6 major functional groups. Adding plants from different functional groups could provide a wider range of benefits to the system: Cool Season Grass (CSG), Warm Season Grass (WSG), Cool Season Broadleaf (CSB), Warm Season Broadleaf (WSB), Cool Season Legume (CSL), Warm Season Legume (WSL).
- High precipitation regions: Eliminate excess water on poorly drained soils, reduce runoff, increase water infiltration, improve physical processes.

Goals

- What are your goals?
  - Cover crops may serve more than one purpose, but when selecting for contracting it may be best to select the primary purpose that aligns with the producer's goals.

Single Species

- Pros: Clear goals (ex: suppress particular nematodes with Sunn hemp), ease of planting, uniform establishment and maturity
- Disadvantages: Increased risk of poor establishment, limited range of benefits to system, grain/grass may tie up N after incorporation, legume may release too much N too fast after incorporation

Multispecies Mixes

- Optimize C:N (25-30:1 at maturity promoting slow-release N)
- Reduce risk of failure (but requires planning)
- Utilize allelopathy to hit a broad spectrum of controls
- Benefit insect populations (species specific)
- When developing mixes consider:
  - Timing/maturity of components
  - Competitive nature of components
    - Don't want highly competitive cover crop outcompeting less competitive cover crop because just throwing money away
  - Termination and establishment requirements
  - When one may not thrive, another fills in and takes its place
  - Not all seasons the same via weather

Timing:

- What is your timing?
  - Need to see crop plan, when is your window of opportunity to plant, when is nothing growing
    i. Long season vs short season crops
    ii. Previous crop
      1. What was the previous crop
      2. When will be pulled out
      3. How will it be terminated
      4. What will the planting bed look like following previous crop
      5. How will residue from previous crop affect cover crop
      6. Fertility applied to previous crop
    iii. Next crop
      1. What is the next crop
      2. When will the next crop be planted
      3. How will the next crop be planted
      4. What does the planting bed need to look like
      5. How will residue affect the next crop
      6. Fertility applied to next crop
    iv. Cover crop timing
      1. How long will cover crop remain in place
      2. How long does it take the cover crop to grow, get established enough to meet the purpose
      3. What fertility does the cover crop provide
- Planting too late may prevent cover crop from accumulating enough biomass to provide benefits

Species Selection

- Growth form of crops
- Growth form of cover crops
    - Competitive species may take up light, nutrients, and water reducing the benefits of the cover crop
    - Species with similar growth forms often compete for resources, while species with different growth forms are more likely to be complementary
- Well adapted varieties
- Families: Amarantheaceae, Brassicaceae, etc. will impact disease and pest pressures
- Categories: CSL, WSL, CSB, WSB, CSG, WSG
    - Grasses:
        - Establish quickly (good for weed suppression and erosion control)
        - High biomass
        - Dense fibrous root systems (erosion control, C sequestration, soil quality)
        - Scavenge and store soil nutrients (reduce leaching and transport)
    - Legumes:
        - Most legumes have a beneficial relationship with rhizobium which form nodules and live in the plants roots, convert N2 gas from atmosphere to plant available nitrate (nitrogen fixation) in exchange for sugars from the plant.
            - Supports plant and others in proximity to legumes with log
        - Biomass
        - Attract beneficial insects
        - Suppress weeds
        - 60-200 lbs. N/ac fixed from atmosphere depending on species
        - Fix atmospheric nitrogen: Rhizobia bacteria forma symbiotic relationship with plant root, converting atmospheric N to usable ammonia in exchange for sugars from the plant
            - Support plant
            - Support other plants near legumes with nodules
            - If treat like green manure (incorporation) all N concentrated in tissues goes directly back into the soil
                - If harvest, export huge amount of the N produced through relationship
                - Just leaf residue, more similar N to grain soaking up N in soil
        - Reduce erosion
        - Biomass production
    - Pollinators/beneficials
    - Living pathways
    - Ex:
        - Cowpeas/buckwheat: Fast establishment/growing
    - Intersowing/nurse crop
        - Warm season vs cool season
        - Alfalfa=cs, buckwheat=ws
        - Buckwheat creates microclimate under soil surface

- Cooler, more soil moisture
- Helps alfalfa establish, if exposed is hotter, drier, less able to establish
- Buckwheat terminated by mowing once flowering
- Alfalfa left underneath

- Grasses and broadleaves
  - SOM production, weed suppression, nutrient accumulation, biomass (mulch potential), pollinator/beneficial support
  - Mustards: glucosinolates = natural soil fumigant against Verticillium, Rhizoctonia, Fusarium, Pythium Sclerotinia
  - Compaction relief
  - Ex-cereals
    - Winter rye and winter wheat
      - Easy to grow, fast to establish, widely applicable
      - Rye: common late season fall overwintered CC
        - Germ at very cold temperatures
        - High biomass
        - Allelopathic effects-inhibits germination of small seeded weed species
      - Wheat: earlier seeding date, matures a little later, puts out slightly less biomass
- Grass/legume combinations
  - Cold winter example: Hairy vetch or red clover plus winter rye
  - Milder winter example: Bell beans plus oats
  - Balance C:N after incorporation
    - Grasses=C rich, legumes=N rich, grown together the N helps break down the C (possibly important for breakdown of residue for following cash crop planting)
  - Growth rate
    - Grasses generally faster growing, legumes generally slower growing. Grasses can get established faster and outcompete weeds that may prevent legumes from establishing as well.
  - Height
  - Grasses generally taller, legumes generally shorter. Grown together provide better coverage of soil from sun, prevent weeds better.
  - Rye: high C:N, hard to break down quickly
  - Add legumes into mix, balance, drop C:N, easier for soil microbes to digest the mix and get residue to break down into soil structure faster
  - If don't want to break down quickly, plant high carbon cover crop
    - Pure wheat, rye, barley, get lasting residue
- Brassicas
  - Plant earlier than small grain cover crops for maximum benefits (difficult to use in cash grain rotations)
  - Fall planted brassicas fit into vegetable cropping systems following early harvested crops
  - White/brown mustard popular fall planted cover crops in potatoes in E WA
  - Establishment:

- Well drained soils, not poorly drained
- PH 5.5-8.5
- Winter cover crops: establish as early as possible (4-6 weeks before average first 28F freeze)
- Min temp = 45F, max = 85F

- Winter hardiness
  - Late planting likely results in stand failure, reduce biomass and nutrient scavenging
  - Not all species winterkill
- Winter vs spring
  - Some winterkill, better seedbed prep in spring
  - Fall planting preferred, planting conditions (soil temperature, moisture) more reliable, cover crops produce more dry matter
- Mixtures:
  - Mix with small grains, other brassicas, legumes
  - Very competitive
  - Adjust seeding rate to ensure adequate growth of companion species
- Killing
  - Winter kill
  - Spring: Mow, incorporate, roller crimper when in flower
  - No till for mature brassicas: Flail mowing. Evenly distribute residue to facilitate planting operations and reduce allelopathic risk for cash crops.
- Nutrient management:
  - Need adequate N and S.
  - S needs and uptake exceed other species because S is required for oil and glucosinolate production. 7:1 N:S ratio in soil optimum for growing rape, N:S from 4:1-8:1 work well for brassicas in general.
  - N: enhance N uptake and early growth
  - Rape: Scavenge P by making insoluble P more available to them via excretion of organic acids in root zone.
  - Decompose quickly. Decomposition and nutrient turnover from roots (C:N of 20-30) expected to be slow than from shoots (C:N of 10-20), but faster than winter rye.
- Rapid fall growth
  - Great biomass production
  - Nutrient scavenging
    - Immobilize less N than some cereals, much of N taken up becomes available for uptake by cash crops early late spring
    - Some root to 6'+ (most belowground production when soil moist and easy to penetrate)
    - Most mustards = fibrous root system
    - To maximize: Plant brassicas earlier than winter cereal cover crops in most regions

- Pest management: most brassicas release higher levels of chemical compounds toxic to soil borne pathogens and pests (nematodes, fungi, weeds)
    - Mow and incorporate to maximize natural fumigant potential
        - Fumigant chemicals produced only when individual plant cells are ruptured
    - Pest suppression: Result of glucosinolate degradation into biologically active sulfur containing compounds (thiocyanates). To maximize pest suppression: Incorporate during vulnerable life stages of pest.
    - Biotoxic activity low compared to commercial fumigants. Dependent on region and operation.
    - Biotoxic activity can stunt cash crop growth, so avoid direct planting into just killed green residue.
- Disease management:
    - Some data showing brassicas can decrease Rhizoctonia, Verticillium, powdery scab, common scab with incorporation
- Nematode management:
    - Some data shows reduction in root knot nematodes
- Weed management:
    - Fall: Rapid growth, canopy closure
    - Spring: Inhibit small seeded annual weeds (pigweed, shepherds purpose, green foxtail, kochia, hairy nightshade, puncturevine, long spine sandbur, barnyard grass)
    - Must be supplemented to cultivation to avoid crop yield loss later in season
- Option for winter/rotation in vegetable/specialty crops (potatoes, tree fruits)
- Option for row crops for nutrient capture, nematode trapping, biofumigation
- Some = large taproot, break plow pans better than fibrous roots
- Winter kill brassicas decompose quickly

- Precautions:
    - Don’t pant in rotation with other brassica crops (family pests, volunteers)
    - Black mustard = Hard seeded, potential weed problems
    - Rapeseed = Erucic acid and glucosinolates (internal toxicants). Compounds = antinutritional and a concern when feeding to livestock.
    - Winter rape = Host for root lesion nematode.
-

- Combinations don’t put all your eggs in one basket, prevent risk of whole crop failing across whole field/bed

Equipment

- What equipment is available? What kind of system (no till, reduced till, conventional till)
    - Bed preparation tools
    - Planting tools
    - Termination tools
    - Common tools: Broadcast seeder, cultivating baskets and lely tines, cultipacker, drill, roller crimper, plow

Residue

- High residue crops like sorghum sudan, if 12' tall, takes a long time for residue to break down and stop obstructing activity, may need wider window for sorghum sudan to break down before put crop in
    - How much time do I need to have bed fallow so when I need to seed carrots, I can get bed ready
- Battle residue because high biomass cover crop and trying to seed carrots or salad mix into (problem)
- Residue management can be hardest part of cover cropping

Climate

- Soil temperature: Need to know when the soil temperature hits specific temperatures for germination of cash crops and cover crops.
- Air temperature: Need to know average dates of green up, frost, etc.
- Need to know how far ahead of any Persephone period crops need to be planted. These will be different in every area.
    - Ex: Recommend to get fall cover crops in by 9/1 to get cover crops up and established by first frost 10/6 to have sufficient cover through the winter season

- Need to know growing season
- Climate and local growing conditions
    - Dry/wet
    - Cold/hot
    - Windy
    - Microclimates in garden
        - Up on a hill with lots of wind and sunlight and dries out quickly
        - Shady spot, hold water better, not as much growth

Weather:

- How will weather affect plan?
- Temperature
    - Different years see soil temperatures and air temperatures increase and decrease on different dates, will need to monitor both soil and air temperatures
        - Affects planting and winter kill
- Precipitation
    - If depending on precipitation to germinate and grow cover crop, this will change each year. Need to have backup irrigation plan.

Establishment

- Soil
    - Wet/dry: Does this impact preparation/timing
- Size of planting
    - Affects tools
- Tools
    - Based on system, availability
- Crop plan
    - Residue management
- Site preparation
    - Provide best conditions for
        - Germination
        - Seed to soil contact
    - Individual needs for different seed sizes/crop types
        - Small seeds: Finer soil texture, consistent, evenly worked, consistently moist, compacted surface (ex: teff)
        - Large seeds: Can take more residue/clumps/clods, more energy in seed (ex: field peas)
    - Plow/disc/cultivator vs stale seed bedding vs no till vs broad fork/rake/tilther
- Seeding
    - Depth: Species dependent (smaller seeds generally shallower)
    - Rate: Species dependent
    - Broadcast
        - Throw seed out, compress for good seed to soil contact for good germination
        - Pros: Scalable, little or no equipment at small scale, fast
        - Cons: Higher seeding rate to account for losses, less precise seed placement, typically requires an additional pass to incorporate
    - Drill
        - Create furrow, drop seed at specified rate, cover up
        - Pros: Accurate seed placement, single pass planting, lower seeding rates, better conditions for germination
        - Cons: Requires special equipment
        - Small scale: Same as large scale
            - Furrow with hand/tool, cover, compact

- Push seeders (ex: Earth way, Jang)
- Fall dormant seeding: Area and species dependent
  - Would recommend reaching out to Area or State specialists with appropriate JAA

- Water Management
  - Give irrigation to crop early: More consistent germination, better results
  - Challenge: Use water for cash crops, infrastructure may be in different location, may also use precipitation
  - Time seeding before rain/precipitation
  - Dry areas
    - Certain species better for drought tolerance
    - Ex: Sorghum sudan, cowpeas, sweet clover, mustards
  - Spring/fall with more moisture, helps cover crops grow
- Weed Management
  - If weeds get ahead of cover crop, better to work it in than have it go to seed (but cover crops can act as weed control)
  - Ex: Oats already gone to seed, terminate, turn into another flush of oats (cover crop becoming weed)
  - Ex: Canop of cover crop, might not notice infestation of weed species under cover crop (cover crop facilitating weed growth)
    - NEED to check under canopy to find out what is happening
  - Unless VERY dirty, low-quality seed, weed seeds should not be introduced through the seed itself
- Goal = Good germination
  - Without good germination, opportunistic wed species get head start on cover crop/cash crop.
  - Provide good conditions early on to outcompete weeds.

Weed/Pest Control

  - Put in non-host species so don't have continuous cropping system of same crop or same host from year to year
    - Ex: tomatoes year after year, pest populates tomato crop every year because host present every year, tomato residue in soil every year for pests to hide
    - Fix: tomato – rye/clover: pest won't host on those species, may work out of system, create break in system, nowhere for pathogens to survive
  - Insect pests (cucumber beetles love cucurbits)
    - If introduce flowering species that provide habitat and nectar for beneficials but not for cucumber beetles, interrupt pest cycles and can't build populations to economic thresholds
    - Need to understand life cycles of what is trying to eat your crop
    - If cover crops will serve as host for pests
  - Ex: broccoli (brassica) (clubroot) and introduce cover crop to help, DO NOT CHOOSE ANOTHER BRASSICA

Termination

- What equipment available for termination
- Timeline
    - When is field needed for next crop
        - Immediately: Incorporate
        - Weeks: Allow residue to break down
    - Residue
        - High C:N (winter rye) breaks down slowly
        - Low C:N (buckwheat) breaks down quickly
        - Smaller particles and incorporated residues break down faster
        - Larger particles and residue on surface break down slower
- Species of cover crop
    - Characteristics can make easy/hard to manage
- Stage of production
    - Where in lifecycle is cover crop when trying to terminate
    - Do I have enough time to get the cover crop to the point I need it to be at to terminate
    - Ease of termination depends on this
    - Ex: Very tall rye at anthesis can be crimped, if mow also no issues with termination
        - Prior to anthesis: Will Spring back up
    - Ex: Red clover, mowed multiple times in season during pure vegetative growth, will likely not terminate, once in full bloom and mow, likely will not come back
- Priority: Prevent cover crop from setting seed (can become weed problem)
- Winter kill vs winter hardy
    - Winter hardy: Sufficient cold tolerance to survive winter conditions. If resources are available (light, warmth), these species may continue to grow. If not, these species may go dormant until conditions allow growth in the spring.
        - Benefits: Established roots through winter and extended growth periods increase erosion control and biological activity.
        - Some species can be sown after summer cash crops are pulled out in early fall
        - Ex: Winter rye, winter wheat, hairy vetch, some clovers, winter peas, annual ryegrass (area dependent)
        - Spring growth may need to be managed.
            - Ex: Mow and incorporate
            - Ex: Crimp and tarp (use as mulch for spring/summer cash crops)
        - To avoid possible nitrogen, tie up as residue decomposes: Possibly need to delay planting of cash crops 2-3 weeks
    - Winter kill: Lots of aboveground biomass produced during summer/fall, terminated, mulches field or bed and protects bed from erosion.
        - Ex: Oats, field peas, oilseed radish, mustard (can endure some frosts)
        - Ex: Warm season species like buckwheat, sorghum-sudan, and pearl millet (dies much earlier/easier)
        - Need to sow early enough in summer/early fall to get enough biomass production prior to winter kill time period to provide benefits

        - Typically sown in spring/summer or under sown in another crop during the spring/summer

- Equipment
    - Mow
        - Quick termination
        - Flail preferred, rotary works
            - Flail: Chops into small pieces, breaks down faster, expensive, not always available
            - Rotary: Push mower, weed whacker, hand cutting, larger pieces, breaks down slower, more readily available
        - Larger/smaller size of residue affects decomposition rate
            - Sometimes want large particle size
                - Lay flat (sickle bar mower, weed whacker, rotary)
    - Crimping
        - Lay flat
        - Do partial damage up stem to prevent vascular tissues from sending water and photosynthates across stem, prevents from growing, don't want to sever and break into smaller pieces. Just enough pressure to prevent vascular system from working.
        - Good mulch, can plant directly into
        - Ex: Roller crimper, t-posts on ropes, 2x4s on ropes (large or small scale, effective)
        - Requires correct timing
    - Tarping
        - Clear = Solarization
            - Need sunny weather, high heat to terminate (otherwise creates greenhouse)
        - Opaque = Occultation
            - Smother, wait for crop to use up energy resource and die back
                - Excellent results, don't need to turn soil
    - Tillage
        - Rake, disc harrow
        - Deep tillage: Buries residue fastest creates most soil disturbance
    - Chemical
- Terminating too late may result in nutrient immobilization or soil water deficits that could be detrimental to subsequent cash crop
- Incomplete termination can occur, especially when cover crop in advanced growth stages

Raised Beds in Field:

- Raised beds
    - Flat field vs raised beds = more contour
    - No different in how choose or manage individual species unless try to maintain permanent foot path/ perimeter to bed because may get in the way of maintenance
    - Almost the same
    - Opens more possibilities
    - Raised beds in field: increased air flow, increased drainage, beds dry faster, can get in earlier

Small Scale Garden Beds:

- Smaller garden beds (containers, box): Efficient use of space
    - Smaller footprint, get as much as you can out of the garden, do I want to forgo bed space for strawberries for oat cover crops
    - Identify goals, manage systems accordingly
- No hard and fast rules in terms of management other than
    - Fixed space to manage with tools (limiting factor)
        - Residue
        - Termination

Soil Testing:

- Determines which species will be most beneficial
- Need to know what's going on, otherwise it's guesswork
- May need a micronutrient, wouldn't know unless have a test
- Healthy, balanced soil will grow healthy, balanced plants (cash crop or cover crop)
    - Cover crops can be used to get to that point but cover crops also need food, water, good soil to root into

Insectaries:

- Pollinators: Pollinate fruiting crops (bees, butterflies, moths, etc.)
- Predators: Help manage garden pests (lady bugs target aphids, lacewings target aphids, parasitic wasps, hover flies, etc.)
- Habitat/Shelter
    - Shelter, nesting, overwinter habitat for beneficials
    - Diversity of vegetation provides necessary shelter for insect population growth
- Food source
    - Pollen and nectar for pollinators
    - Larger pollinator population can lead to improve pollination of cash crops
- Penn State found early season cover crop have equal or greater effect in mitigating pest pressure compared to insecticides

- Warm season: Buckwheat-Long flowering period, Polyganaceae
- Common species: Clover, hairy vetch, phacelia, alfalfa
- Benefits seen from keeping insectaries close to cash crop
- Grasses/grains: Provide habitat for beetles, spiders, egg habitat for beneficials
- Flowers/herbs: Nectar, pollen, improve survival of natural enemies of common pests
    - Apiaceae: Umbels of tiny, aromatic flowers
        - Angelica, Ammi, anise, caraway, daucus, cilantro, dill, fennel, parsley, Queen Anne's lace, asafoetida
    - Asteraceae: Easily accessible pollen
        - Aster, blanket flower, China aster, coneflower, cosmos, goldenrod, sunflowers, tansy, yarrow
    - Lamiaceae: Tiny flower with lower lip for beneficials and hummingbirds
        - Bee balm, basil, catnip, lavender, lemon balm, marjoram, oregano, sage
- Brassicaceae: Asian greens, broccoli, cabbage, kale, mustard, turnips flower
    - Sweet alyssum = Brassica, used for flower rather than production vegetable.
        - Lots of tiny flower attractive to predators like ladybugs, hoverflies, parasitic wasps, green lacewings

Nutrient Cycling

- Either a scavenger of soil N or a producer of soil N (legumes can do both)
- Scavenging N
    - Non legumes will scavenge/trap soil nitrate that can move into groundwater. Always some nitrate leching from residual N fertilizer or natural decomposition of soil OM. Annual cropping systems are "leaky" due to long fallow periods after harvest in fall and planting in spring. Most leaching occurs during this fallow period, since nothing is growing therefore nothing can take up N. Cover crops can be implemented during this fallow season to take up N and release it at a more beneficial time later.
    - Ex: Grasses (cereal rye, annual ryegrass), brassicas (daikon radish)
    - Legumes will scavenge residual N before producing own N, but establish/grow slower so not normally planted for purpose of scavenging N
    - Amount scavenged depends on growth of cover crop and N available in soil
        - Manure applications: Greater available N (and greater need for cover crop) (ex: 80-100 lbs./ac + available in cover crop)
        - No manure applications: 10-40 lbs./ac available in cover crop
- Producing/fixing N
    - Legumes
    - Amount N fixed depends on growth and species
    - Must be inoculated before fixing N
    - Ex: Crimson clover, hairy vetch, Austrian winter pea
- Availability of N scavenged/produced
    - How/when does N become available for next cash crop?
    - Depends on:
        - Age/stage of plant when terminated

        - Vegetative: higher N concentrations than reproductive stage, will decompose faster
    - N%
    - C:N
        - High ratios (greater than 25:1), decomposing cover crop residues first immobilize N from soil/fertilizer N additions. After time will N start to be released (mineralized)
    - Plant composition
    - Weather (temperature and moisture)
  - Grass cover crop: terminate while vegetative if growing a high N user cash crop (ex: corn). If cover crop gets to reproductive phase before termination, more N immobilization after termination and good application of starter N fertilizer should be used.
  - Not all N scavenged by cover crop will be available next season
  - Some scavenged N builds organic matter
  - After multiple years of cover crops and increase in soil N content and organic matter, likely be possible to reduce fertilizer N rates for similar crop yield
  - Brassicas (ex: daikon) winter kill most years
    - "Early termination" combined with lower C:N means radish will decompose quickly in early spring, release N earlier than when next cash crop can use it
    - 2-way mix: Daikon and winter kill grass (ex: spring oats) effective way to scavenge N but keep N in soil longer in spring while removing management challenge to producer of termination timing in spring
  - Legumes and most grasses in vegetative stage C:N ratios = 10-15:1
    - Decompose and release N rapidly after termination
    - Half N in aboveground biomass will be available over time window of 1-2 months (weather dependent)
    - If legume terminated too early, some N may be lost before cover crop can use it
  - N vulnerable to leaching when present in nitrate form. Has negative charge, does not bin dot negatively charged soil particles. As water moved through soil, carries nitrate. Most cover crop roots in topsoil and will use N in topsoil, preventing from moving to lower layers.
  - Grasses and brassicas most suitable for taking up N that can be leached
    - Decrease nitrate leaching by 50% compared to fallow rotation
- Phosphorus availability
  - Not prone to leaching
  - Often unavailable to plants because resides in soil in inorganic form
  - Mycorrhizal fungi associated with cover crops efficient P scavengers and help absorb from soil into organic form in plant

Organic form readily available for subsequent crop

Bio controls

Bio controls: More than JUST pest control. Growers must learn life cycles of pests, type of beneficials that control those pests, kinds of plantings that harbor desired beneficials.

- Remove overwintering habitat or other sources of pest
- Establishing insectary plantings which can be individual clump or container plantings, perennial hedgerows, and/or annual strips in field
- Release purchased beneficial insects when needed
- Planting trap crops to lure pests away from cash crops
- Scheduling crops to avoid high pest populations
- Building nest boxes for birds and bats

Beginner:

- Single species
  - Understand individual species better first, how function in specific soils in climate
- Winter kill
  - Residue management easier
  - Reliable
- Ex: Peas and oats
  - Big seed, easy to handle, typically winterkill in Zone 5 and colder, easily work soil in spring
- Ex: Buckwheat
  - Easy to grow, quick to set seed though so MUST terminate prior
  - Once flower, cut under/turn under
- AVOID
  - High residue, can be difficult to terminate
    - Ex: Sudan grass, winter rye, winter wheat (phase 2)

Advanced:

- Mixes
- How can I have two things happening at once?
  - Under sow clover into broccoli in fall
    - Once broccoli done, clover there, continues to pump N into soil, can terminate in spring or let continue to grow

Recommendations Against Cover Cropping:

- Small scale farm
    - Some farms don't have space, need to maximize production
    - Can build fertility through compost, mulches, accomplish same goals without taking area out of production
- Problem weed cannot get rid of
    - Bare/fallow, light tillage multiple times through season, allows weed to germinate, flush, till, and repeat
    - Use sparingly
- Some dryland cropping system with limited precipitation
    - Summer planted cover crops in wheat/fallow can reduce available soil water to subsequent wheat crop and reduce wheat yields
        - Mitigate yield losses: Terminate cover crops early to allow soil water recharge before planting next cash crop

Examples:

- Mix of winter kill and winter hardy: Winter rye, field peas, ryegrass, crimson clover, hairy vetch. Peas, clover, ryegrass will winter kill. Hairy vetch and winter rye will regrow in the spring.
- Forage radish planted late August, dies first hard frost, living cover and decomposing residues suppress winter annual weeds
- Mustard in tillage intensive, high value vegetable production systems because relatively easy to incorporate prior to planting vegetables. However, growth and biomass production by mustards in winter not as reliable as other species.
- Warm Season: Cowpea and sorghum (weed control)
    - Sorghum = heavy N feeder, tall, upright, allelopathic
    - Cowpea = N fixer, dense canopy
- Cool Season: Hairy vetch and cereal rye
    - Rye (and cereals) germinate and establish root systems faster than legumes and low the soil N
    - Nodulation of legume roots and atmospheric N fixation greater when soil N low, so nodulation and N fixation increased in mixtures
    - Rye roots = fibrous, so prevent frost heaving damage to overwintering vetch
    - Rye – Upright, strong stems support vetch vines during spring growth
    - Biomass production and weed suppression better through combination than either species alone
- Winter kill mix: Sudan grass, tillage radish, lentils, berseem clover
    - Dies in winter months
    - Easy to manage residue in spring, turn in and plant
- Winter kill mix: oats, peas, vetch:
    - Mix legumes into different blends to get benefits
- Spring lettuce
    - Early in early out

    - Big window when comes out in June/July
    - Could follow with fall greens BUT if have window during summer, could plant in buckwheat
    - Work backwards from what you're going to plant with garden crops to find where you can start to incorporate cover crop
- Common mixes:
    - Peas, oats, vetch (spring green manure)
        - Peas and oats winterkill in cool climates
        - Vetch may overwinter – think about termination
    - Rye, ryegrass, clover, vetch (fall green manure)
        - Some overwinter, some winter kill
    - Rye and vetch
    - Buckwheat and cowpea
        - WS – broadleaf and legume

Additional Washington Guidance on CSP Enhancements:

E340A Cover Crop to reduce soil erosion: N/A

E340B Intensive cover cropping to increase soil health and soil organic matter content: N/A

E340C Use of multi-species cover crop to improve soil health and increase soil organic matter:

In addition to the criteria specified in the National job sheet E340 the following additional criteria apply in Washington:

- If using plants/crops that have not been historically proven in the county the participant must be working with LGU, extension, and/or conservation districts. Consult Area or State Specialist if further cover crop assistance is needed.
- Seeding rate for geographical areas with less than 14" precipitation will target 10 to 15 seeds per sq ft. Geographical areas with greater than 14" precipitation will target 20 to 30 seeds per sq ft.
- Use the following resources to select cover crops appropriate for your climate, cropping system and enhancement purpose.

PNW Cover Crop Selection Tool:
https://www.nrcs.usda.gov/wps/portal/nrcs/detail/plantmaterials/technical/toolsdata/plant/?cid=nrcseprd894840

Additional Resources found on WA eFOTG Section 1, Reference Lists: Technical Notes by Discipline:
• WA Agronomy Technical Note 2 – Winter Cover Crops for Irrigated Sandy Soils in the Columbia Basin
• WA Agronomy Technical Note 10 – Planting Dates for Fall Cover Crops in the Irrigated Columbia Basin
• WA Agronomy Technical Note 9 – Management of Residual Nitrogen with Cover Crops
• WA Agronomy Technical Note 16 – Cover Crops
• WA Plant Materials Technical Note 18 – Green Manure and Cover Crops for the Inland Pacific Northwest

Additional Resources:
• Managing Cover Crops Profitably: Managing Cover Crops Profitably, 3rd Edition - SARE

E340D Intensive orchard/vineyard floor cover cropping to increase soil health: N/A

E340E Use of soil health assessment to assist with development of cover crop mix to improve soil health:

In addition to the criteria specified in the National job sheet E340 the following additional criteria apply in Washington:

If using plants/crops that have not been historically proven in the county the participant must be working with LGU, extension, and/or conservation districts. Consult Area or State Specialist if further cover crop assistance is needed.
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Additional Resources:
• Managing Cover Crops Profitably, 3rd Edition: Managing Cover Crops Profitably, 3rd Edition - SARE

E340F Cover crop to minimize soil compaction: N/A

E340G Cover crop to reduce water quality degradation by utilizing excess soil nutrients: N/A

E340H Cover crops to suppress excessive weed pressures and break pest cycles: N/A

E340I Using cover crops for biological strip till: N/A

E340J Cover crop to improve moisture use efficiency and reduce salts:

In addition to the criteria specified in the National job sheet E340 the following additional criteria apply in Washington:

If using plants/crops that have not been historically proven in the county the participant must be working with LGU, extension, and/or conservation districts. Consult Area or State Specialist if further cover crop assistance is needed.
Seeding rate for geographical areas with less than 14" precipitation will target 10 to 15 seeds per sq ft.
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