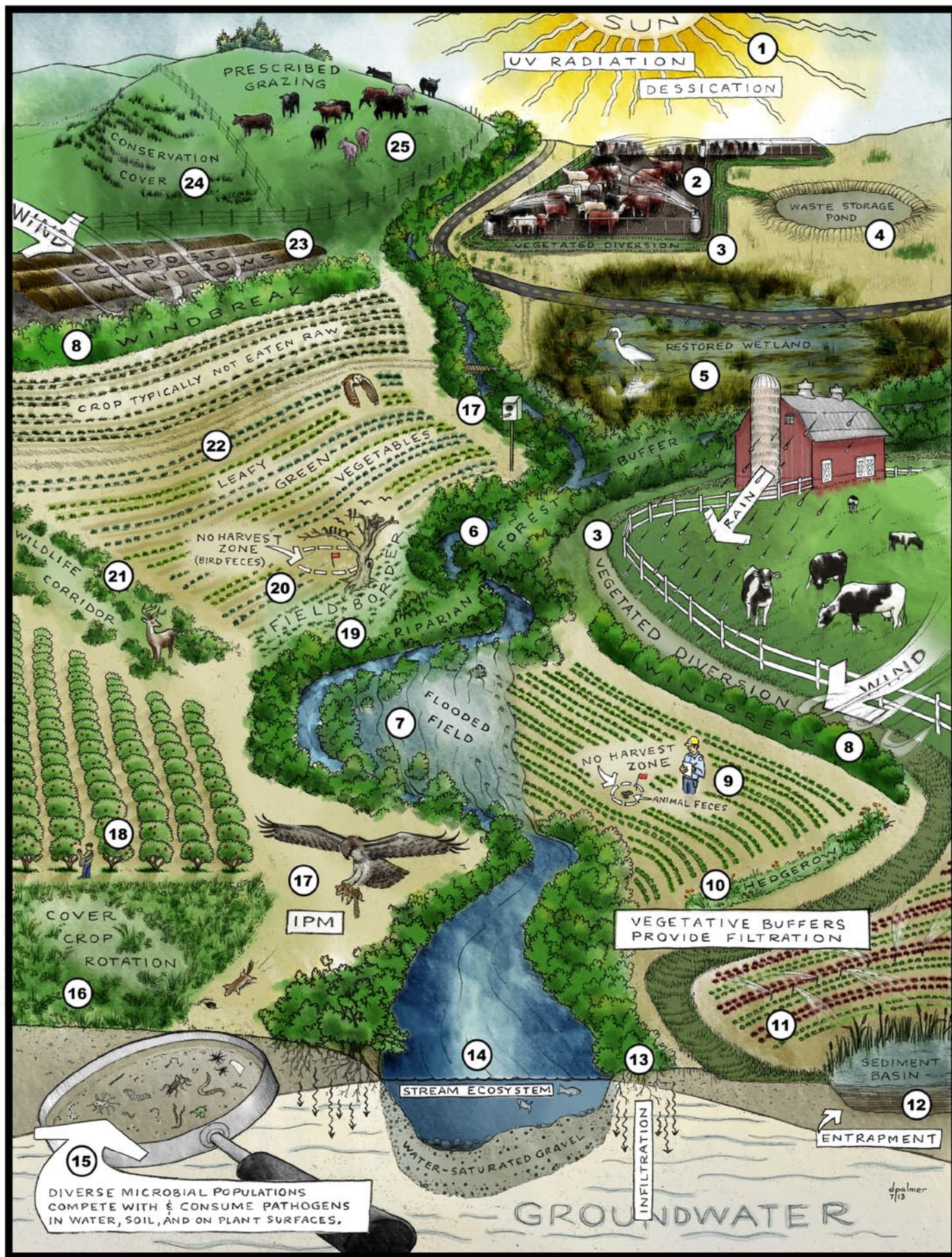


# Healthy Diverse Ecosystems Help to Keep Pathogens in Check



Not to Scale



## Illustration Key

*Note: The Healthy, Diverse Ecosystems Help Keep Pathogens in Check illustration is not drawn to scale; it serves as a visual summary of the conservation practices and food safety actions used to address food safety referenced in this document. These practices and actions do not provide complete and conclusive protection against food-borne pathogens on a given farm/ranch, and some vegetative conservation practices may attract wildlife that can vector pathogens. When implementing in-field practices to address food safety, one should take into account the conditions present on the farm/ranch and use this information to assess the effectiveness of a given practice in reducing the risk of food-borne pathogen contamination of crops.*

**1. Sun:** UV radiation from the sun may inactivate recently deposited pathogens on the surfaces of soil and leaves, as well as in clear water. The sun also facilitates the desiccation of pathogens, which leads to pathogen reduction.

**2. Dust from animal activity** is reduced with the application of water by sprinklers and with manure harvesting. Reducing emissions and removing manure proactively are cost-effective means of mitigating pathogen transfer.

**3. Diversions** redirect water running off of confined animal feeding operations to waste treatment and sedimentation lagoons, preventing the movement of waterborne pathogens to nearby farm traffic areas, fields and waterways. Vegetated diversions also intercept organic matter and soil carrying pathogens running off pasture, and divert potentially contaminated water away from specialty crop fields. The diversions slow pathogen dispersal, and provide a matrix for beneficial bacteria and protozoa that compete with and consume pathogens. Plants should be selected for low-flow filtering capacity and the ability for high flows to flow through the vegetation. Selection criteria should also consider how well air and sunlight are able to penetrate into the vegetation, as the cool, moist, shaded interior vegetation may provide favorable habitat for pathogen survival. Otherwise additional maintenance will be required that regularly harvests and removes excess vegetation.

**4. Waste storage pond** temporarily stores waste, such as manure runoff from confined animal feeding operations, thereby reducing pollution potential in the landscape. The waste storage pond should be properly designed and maintained so that it does not overflow. Food safety Good Agricultural Practices (GAPs) recommend that the effluent from the ponds not be used on crops typically eaten raw. Monitoring of animal movement around the pond and between waste handling areas and crop fields should be a scheduled activity.

**5. Restored wetlands** can considerably reduce pathogen transport by slowing the water, which increases the interaction time, and providing a matrix for beneficial microbes. The diverse plant and microbial community establishes desirable interactions that serve to limit pathogen persistence. Use of vegetation and designs that facilitate slow moving water over long periods in the wetland allow the best chance for pathogen reduction in water draining from the wetland. The vegetation in the wetland may decrease the ability of UV light to reach the pathogens, which may increase survival. However, pathogens may be retained on vegetation. As water recedes, the pathogens that are retained on the vegetation may be exposed to sunlight and desiccation.

**6. Riparian forest buffers** are vegetated areas along bodies of surface water, including streams, wetlands and lakes. They may trap wind-borne pathogens on their vegetation and filter waterborne pathogens attached to suspended organic-soil particulates and other solids. The diverse plant and microbial community in the buffers encourages interactions limiting pathogen persistence.

**7. Flooded field:** Food safety GAPs recommend that crops typically eaten raw are not planted on lands that often flood. If and when a flood occurs, it may take time for pathogens present in the soil to die off. Depending on the frequency of floods, the field could be fallowed for a period, replanted to a cover crop, or possibly, permanently taken out of production with the restoration of riparian habitat.

**8. Windbreaks** can trap dust containing pathogens and prevent it from entering specialty crop fields. Plants should be selected with foliar and structural characteristics to optimize dust/pathogen interception. If interior vegetation is too dense, it may provide a cooler, moister and shadier environment, which may create a favorable conditions for temporary pathogen survival.

**9. Evidence of animal intrusion in a crop field should be monitored.** Food safety GAPs recommend that farmers monitor for animal feces and signs of feeding, and when found, a no-harvest buffer is placed around the contaminated source, or other measures are taken to reduce risk of harvesting the contaminated crop. The following considerations all factor into determining the appropriate risk reduction actions taken: the type and number of animals; whether they are present intermittently or continually; if they are there because of food, a movement corridor, or live next to the crop; and if they are seen initially before planting or right before harvesting.

**10. Hedgerows** may trap waterborne pathogens in their root systems, and wind-borne pathogens on their vegetation. Shaded interior of the vegetation may provide favorable conditions for temporary survival of pathogen if too dense.

**11. Irrigation:** Food safety GAPs recommend using sources of irrigation water that are adequately free of contamination. Management techniques that promote infiltration of the water into the soil can reduce runoff and may aid in reducing the movement of pathogens already present in the field. Techniques that aid in infiltration include soil quality management that increases porosity and improves structure, and irrigation management that keeps soil from becoming saturated.

**12. Sediment basins** capture and detain sediment-laden runoff that may contain pathogens. Correctly designed, basins allow sufficient time for the sediment to settle out of the water. With moist, cool conditions, the basin may support the survival of pathogens. Having time for the sediment to settle out of the water. With moist, cool conditions, the basin may support the survival of pathogens. Having a sediment basin that dries down as rapidly as possible helps to alleviate these moist conditions and helps reduce pathogen survival. Moist sediment that is removed from the basin and put on cropland should be treated as contaminated and a time period similar to non-composted soil amendments between its application and the next crop's harvest should be established.

**13. Riparian forest root zone:** The roots of the riparian forest promote water infiltration and provide biological activity. This helps divert pathogens from surface water, and encourages interactions with other soil microorganisms that can limit pathogen persistence.

**14. Stream ecosystem:** In a stream ecosystem where diverse microbial communities exist, they are thought to reduce pathogens by competition, parasitism, and predation. Clear water allows light to reach pathogens, which can lead to their reduction. Flowing water dilutes pathogen populations. Some algae and protozoa may serve as an alternate host for pathogens, allowing pathogens to survive even when environmental conditions are unfavorable.

**15. Diverse microbial populations compete with and consume pathogens in water, soil and on plant surfaces.** When diverse microbial populations are present, beneficial microbes compete with pathogens for carbon and nitrogen, while others kill and consume them. Diverse microbial communities in water and on plants also compete for resources and/or consume pathogens. In some instances, biofilms a matrix of bacteria and carbohydrates can harbor pathogens.

**16. Cover crops:** Rotating with cover crops increases soil organic matter and supports soil microbial communities that may aid in suppressing pathogens. Cover crops may also reduce the movement of pathogens in water run-off by trapping pathogens in their roots and leaves. They can be used as part of a 'waiting-period' between events that might pose contamination risk (e.g. grazing, flooding) and the planting of a crop typically eaten raw. Cover crops also reduce open soil, which helps reduce dust transmission problems.

**17. Integrated pest management (IPM)** of vertebrates such as mice and squirrels can be used as a means of control for pest animals that enter crop fields. Having a few predatory animals, such as hawks or owls, on the farm is less of a risk than numerous prey species. A crop should not be planted directly under a raptor nest box or a roost, so that it is not contaminated with raptor feces. Farm traffic should not carry fecal droppings into the cropped area or equipment and storage yard.

**18. Harvesting orchard fruit** from the tree, not the ground, is recommended by Food Safety GAPs when it will be consumed fresh. Fallen fruit may have come in contact with animal feces.

**19. Field borders** can intercept and reduce waterborne pathogens moving in overland flow from the field. This planting encourages infiltration and serves as a buffer between the field and the riparian vegetation.

**20. Tree bird roost:** Food safety GAPs recommend that a no-harvest zone is established under branches that hang over the field to ensure bird feces will not touch the crop.

**21. Wildlife corridors** allow wildlife to access resources (water, food, and cover) without having to walk across crop fields or leave their preferred habitat.

**22. Crop placement:** Food safety GAPs recommend that leafy green vegetables or other crops typically eaten raw not be planted near manure stockpiles or composting facilities and windrows, or other areas of contamination, as pathogens may transfer to the field via water or wind.

**23. Compost:** Properly managed compost windrows heat up to a temperature that results in significant pathogen reduction. Compost itself supports beneficial organisms that compete with, inactivate, and consume pathogens. Compost that has been allowed to be re-contaminated, or compost that is unfinished could be a source of pathogens; thus, measures should be taken to prevent these below par composts from moving onto adjacent fields through wind or water. For information on proper compost management practices refer to 'Chapter 2: Composting' in Part 637 of the USDA, NRCS National Engineering Handbook.

**24. Conservation cover** is used to establish and maintain perennial vegetative cover to protect soil and water resources on land retired from agricultural production or on other lands needing permanent protective cover that will not be used for forage production. Perennial plants may trap wind borne pathogens on the vegetation and waterborne pathogens in the root system.

**25. Prescribed grazing** uses animals to manage vegetation. It also helps to increase water infiltration, reduce runoff and prevent erosion. This aids in stopping the movement of pathogens in runoff. Grazing animals are a reasonably foreseeable source of pathogens; thus, measures should be taken to prevent pathogens from the animals' feces from moving onto adjacent fields through wind or water.

**Note to User:** Details on the design, dimensions, spacing and maintenance specifications of many of the conservation practices represented here are found on the Natural Resources Conservation Service (NRCS), U.S. Department of Agriculture (USDA) website: [http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/technical/?cid=nrcs143\\_026849](http://www.nrcs.usda.gov/wps/portal/nrcs/detailfull/national/technical/?cid=nrcs143_026849). Jo Ann Baumgartner of Wild Farm Alliance (WFA) wrote the excerpt of this guide with review and substantial technical input from Trevor Suslow at UC Davis and Bill Reck at NRCS, and editing from Community Alliance with Family Farmers (CAFF). The excerpt from this publication provides guidelines and practical tools for use by family farmers. It was supported by the California Department of Food and Agriculture (Specialty Block Grant #SCB11005), Columbia Foundation, Farm Aid, Gaia Fund, Newman's Own Foundation, Organic Farming Research Foundation, True North Foundation, United Natural Foods Inc., Veritable Vegetable, and the NRCS, USDA, under number 69-3A75-10177. Any opinions, findings, conclusions, or recommendations expressed in this publication are those of the authors and do not necessarily reflect the view of the USDA. The information provided herein is offered by WFA and CAFF in good faith and believed to be reliable, but is made without warranty, express or implied, as to merchantability, fitness for a particular purpose, or any other matter. It is intended as an educational resource and not as technical advice tailored to a specific farming operation or as a substitute for actual regulations and guidance from FDA or other regulatory agencies. It is also not intended as legal advice. We will not be responsible or liable, directly or indirectly, for any consequences resulting from use of this document or any resources identified in this document. October 2013.