Washington State Beekeepers Association
Master Beekeeper Certification Committee

Research Paper #1, Submitted by Franclyn Heinecke, 2011

Knowing the Neighborhood for Bees: Information and resources for new beekeepers to use to assess the forage area for stationary, year-round hives.

"The foundation of success in beekeeping is the location. No one should enter extensively upon the production of honey without first inquiring in regard to the flora …."

(Lovell, 1926, *Honey Plants of North America.)*

Introduction:

More than 100,000 people in the U.S. have started keeping bees since 2009 (Bee Culture, 2010). The number of small-scale beekeepers has grown significantly, due to several factors including a growing awareness of honeybee health issues, renewed interests in producing and consuming local foods, and a large number of new retirees and people out of the workforce.

Classes are offered by many beekeeping supply businesses and local beekeeper organizations to develop beginner beekeeper skills and knowledge. In classes and from books, new beekeepers learn to place hives facing South or Southeast for morning sunshine exposure, to have windbreaks North of the hives, to keep hives away from low areas that might accumulate cold air or moisture, and to protect hives from predators (Flottum, 2005; Sammataro, 1998). Few programs, however, include detailed information or resources to help beekeepers evaluate the available forage area for bees before they place stationary hives.

The honeybee hive is perennial, and bees need honey all year long. Honey stores are crucial to winter survival. Pollen is crucial as a protein source for young bees and during brood rearing, most notably for fast buildup in the spring. To maximize nectar and pollen gathering, it is important for beekeepers to understand what plants are available in their area, their bloom time, and what influences a strong nectar flow, among other important hive management skills.

In *The Hive and the Honey Bee,* Ayers and Harman (2008) state that, "… despite its central importance to the … industry, the subject of bee forage has become the neglected half of beekeeping, particularly in the United States. Many beekeepers, as well as the state and university personnel upon whom they rely for information, do not know, much less understand, the bee forage of their area."

This paper reviews bee foraging behavior, covers what is foraged and what influences the usefulness of that material, and gives information and checklists for beekeepers in Washington State to use when assessing the forage area for placement of year-round, stationary hives.

Foraging Behavior of Bees:

> *"The goal of honeybee management is to guide the bees' natural behavior into patterns of activity desired by the beekeeper. Knowledge of bee behavior is essential in management for either honey production or pollination. Honeybees communicate ... by dances ... (which) allows them to become rapidly distributed amongst nectar and pollen plants within flight range."* (Hoopingarner and Waller, 2008, *The Hive and the Honey Bee*.)

Foraging Distance – Honeybees can cover several miles to forage, but they often will stay closer to the hive if adequate forage is present (Blackiston, 2002). Whether bees forage close to or far from the hive, it is important for a beekeeper to understand what forage sources are found within range of placed hives. The amount of available resources, level of competition, and plant productivity influence how far a honeybee will fly.

Gary (2008) asserts that "(i)n general, bees were found to have a strong tendency to forage at the nearest source for each floral species in the area, particularly if competition for the same species is greater at more distant areas," such as when multiple small apiaries are in the area. Additionally, honeybees maximize forage relative to the cost of flying. During windy weather, a close crop of dandelions may be relatively better forage than fruit blossoms found further way. Bees can work less hard for the food when foraging the nearby dandelions.

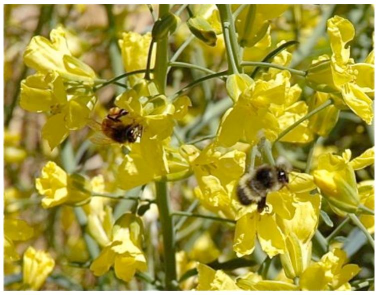
On the other hand, plant production and preferences can stimulate bees to forage further from the hive. Such is the case if bees are located in areas with limited forage, requiring bees to make longer foraging flights. Honeybees can cover 12,000 acres within a radius of two and one-half miles, with a maximum flight range of five to eight miles from their hive (Hoopingarner and Waller, 2008). But, just because honeybees can fly that far, it does not necessarily mean they will always find the needed forage. Modern housing development and monoculture land use practices may leave many miles of land without adequate forage needed for honeybees.

Additionally, longer flights can be detrimental in several ways: more bees face injury or death during long forage flights, overall hive health is compromised because of potential loss of foragers as well as possible limited pollen and nectar coming back to the hive, and surplus honey crops for the beekeeper may be reduced because of bee loss and added stresses to the hive.

Having the Needed Number of Foragers – Beekeepers also need to understand the importance of having a good number of foragers during optimum flower bloom time. The proportion of bees available to forage changes throughout the stages of colony development and time of the year, and is influenced by the type of target crop (Hoopingarner and Waller, 2008). Large colonies have more foragers than small ones. For example, in a strong hive, the ratio of bees to brood may be 3:1, where small colonies may have closer to a 1:1 ratio.

In colonies with more bees at different stages of development, there are more foragers over a longer period of time. In the peak of the season, a colony may have 2,000 new foragers a day. Inexperienced foragers usually stay closer to the hive before expanding to new areas. As already stated, experienced forages can fly two miles or more in search of food. Therefore, it is important for beekeepers to understand what forage is available and its bloom time in order to plan to have the maximum number of bees available when plants are in flower.

Thus, while this paper deals with understanding forage for bees, it is important that beekeepers understand how to successfully over-winter their hives and how to support maximum hive build up so bees are ready when forage becomes available. Such information is beyond the scope of this paper but, nonetheless, important for beekeepers to know when they consider where to place stationary hives.

From left: Honeybee and bumblebee on kale flowers; Pink pollen from cilantro flowers; A pollen forager, fully loaded and returning to the hive.

Finding Pollen, Nectar, Water, and Propolis:

Pollen and nectar are the two most important food sources foraged by honeybees. Bees get their pollen and nectar from a wide range of native, naturalized, and cultivated plants. Bees also forage for water, propolis and, to a much lesser extent, honeydew.

Pollen:

Colony health depends on pollen as much as it depends on honey. Pollen is a complete food for honeybees. It is a protein, and it includes trace amounts of minerals, carbohydrates, oils and sugar. A colony needs from 40 to 60 pounds of pollen per year (Root, 1972). Therefore, beekeepers need to understand the pollen sources and bloom time within forage range.

Pollen reserves are crucial to colony build up and for storage during times of dearth. For example, colonies begin to raise brood in late winter. The protein source is crucial to the developing larvae and for young, newly emerged bees. The colony can rear brood without pollen, but it does so at the expense of adult bees' bodies. Over-winter survival is closely related to the amount of pollen stored in the fall, as an estimated 78 percent of colonies fail to build up if pollen or a protein substitute is not available when colonies are raising brood (Root, 1972.)

The presence of uncapped brood in the hive stimulates pollen gathering, and 15 to 30 percent of available foragers gather it. As bees visit plants, their bodies and legs get covered with tiny pollen grains. Bees gather the pollen with their mouths that are moistened with nectar. The hair-like brushes on bee legs soon become damp enough that the dry pollen is easily swept up. In amazing feats of dexterity, bees can work all six legs and antennae at the same time to transfer pollen to the baskets found in their hind legs, and they can do this while flying (Root, 1972).

Pollen foraging trips are generally much shorter than nectar gathering (Root, 1972). Bees make an average of 10 pollen-gathering trips a day, visiting from 84 (pear) to 100 (dandelion) flowers per load. A strong colony can bring in up to 50,000 pollen loads to the hive daily (Root, 1972). A full pollen load can weigh from 12 milligrams (elm pollen) to 29 milligrams (maple), comprising up to 35 percent of the bee's total weight (Sammataro, 1998).

Dr. Joseph Gottlieb Kolreuter, April 27, 1733–November 12, 1806

He was the first person to propose that plants secrete ***nectar*** *to encourage insects to visit, thereby aiding in pollination.*

Born in Germany, Kolreuter received his Doctor of Medicine from the University of Tubingen, and he was in charge of the extensive collections of the Imperial Academy of Science in St. Petersburg. Kolreuter achieved success in producing plant hybrids and made careful studies of pollen. His finding about nectar was made nearly 30 years before Christian K. Sprengel reported this aspect of nature.

"Kolreuter's strict adherence to the experimental method, his carefully planned and executed experiments, his direct and lucid statements of results, and the clear logic of his inductions and deductions were strictly modern and in striking contrast to the writing of most of his contemporaries."
(*Genetics: A Periodical Record of Investigations Bearing on Heredity and Variation*, 1920, Vol. 5, No. 1, Princeton University Press).

Nectar:

According to Lovell (1926), nectar is a result of a "remarkable and baffling function" of nature. Plant leaves are factories that make carbohydrates – sugars and starches – that are required as food for the plant. But, in nectar secretion, the plant parts with some of the food it has manufactured. Kolreuter was first to point out that the purpose of this nectar secretion was to attract insects needed to pollinate the flowers (Lovell, 1926).

Plant nectaries vary greatly in form and physiology. They can be floral (on flower organs, sepals, petals, stamens and pistils) or extra floral (on leaves and stems.)

Water influences the growth of the plant and the secretion of nectar. The plant cells make nectar. Those cells must be distended with water or a water/sugar solution to order to secrete the nectar. Secretion begins when water is evaporated from the cells. This action is caused by a pressure difference that develops between the distended cells and the outside atmosphere. As nectar is forced out through the ectoplasm due to the pressure difference, more nectar can then be drawn out by osmosis (Lovell, 1926).

While too much rain does not affect nectar flow, bees are not able to get to forage when there are persistent, heavy rains. Dry weather cuts short the nectar flow. Also influencing nectar secretions are soil, humidity, air temperature, sunlight, and altitude.

Plants growing in ***soil*** where they are adapted are more vigorous and produce more nectar (Lovell, 1926). Soil does not act directly on nectaries. No chemical in soil directly stimulates nectar flow; rather, vigorous plants secrete more nectar. For this reason, it benefits beekeepers to know the predominate nature of the soils near their apiaries and what grows well in that type of soil. Alkaline, or lime, soils are good for growing legumes, alfalfa and clovers. Slightly acidic soils provide for the greatest number of plant species (Lovell, 1926).

Nectaries secrete more in ***humid weather*** (Lovell, 1926). Evaporation is checked and more water accumulates in the cells. This action increases the pressure within the cell walls, ultimately forcing more nectar from the plant. Flowers at ***high altitude*** produce brighter colors and secrete more nectar, probably due in great part to the ***increased sunlight*** they receive.

Temperature, however, has a greater influence on nectar secretion than light, humidity or rainfall (Lovell, 1926). Temperatures ranging from 68 to 72 degrees F. are optimum to manufacture sugar in leaves. Higher temperatures make membranes more permeable, the solvent power of water increases and the chemical change in plants happens more readily (Lovell, 1926). On warm, clear days, sugar is made by leaf cells more rapidly and is stored in chloroplasts. At night, the sugars move out of leaves in the form of glucose or dextrose. It is moved to other plant parts where it is used or stored.

During cool nights, growth stops, and the sugar formed during the day is stored. After a cool night, more sugar is available the next day. Conversely, if it is a warm night, sugars formed during the day are used rather than stored. Fifty to 80 percent of foragers gather nectar, with a full load up to 85 percent of the bee's body weight (Sammataro). Once in the hive, the nectar is processed and evaporated to make honey.

Water and Propolis:

Honeybees also gather ***water and propolis***. Bees do not store large amounts of water, but a strong colony can use up to one quart of water a day during hot, dry weather (Gary, 2008). Therefore, close water sources are important to bees. Water is used to:

- Thin honey for larvae food.
- Cool and humidify inside the hive.
- Regulate the hive temperature.
- Moisten brood caps.
- Moisten cells with eggs and larvae to prevent them from drying out.

Propolis, or bee glue, is sometimes overlooked and misunderstood as a forage product used by bees. Gathered from tree buds – especially alder, beech, birch, cottonwood, elm, fir, horse chestnut, and poplar – bees gather propolis in warm weather when it is pliable (Wade and Friedrich, 1996). Propolis gatherers are faithful to that work, spending 15 to 60 minutes to gather one load. Bees use propolis to:

- Secure, or "glue" together, hive parts.
- Close up holes and cracks to protect the hive from wind and rain.
- Line cell walls before eggs are laid.
- Place behind the hive entry so entering bees cross over it.

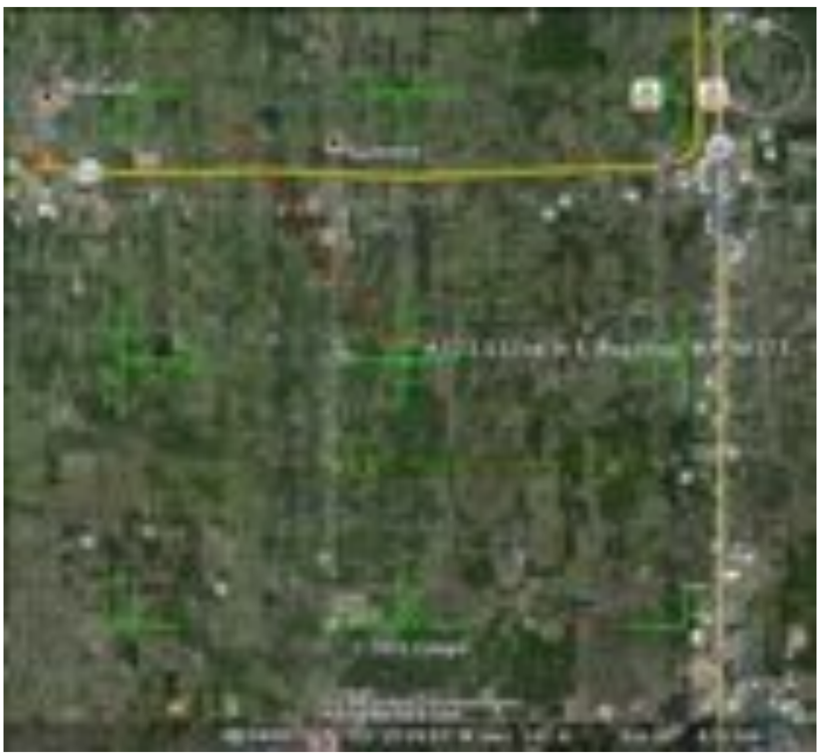
Research on propolis shows why it is important to the hive (Wade and Friedrich, 1996). Propolis is a natural antibiotic. It can be used to immobilize infectious germs, especially gram-positive bacteria and fungi. It is antiviral and acts as an immune system stimulant (Wade and Friedrich, 1996; Schnaubelt, 1995). Propolis consists of about 55 percent resinous compounds and balsams, 30 percent beeswax, 10 percent aromatic oils, 5 percent pollen and flavonols that include polyphenols with aldehydes, esters, and ketones. Those compounds have been shown to be effective in many different ways:

- Phenols have strong antibacterial actions and stimulate the immune system.
- Plant aldehydes are sedative, anti-inflammatory, and antiviral.
- Plant esters are antispasmodic, antifungal, and equilibrating.
- Ketones are cell regenerating (Schnaubelt, 1995).

A little about Honeydew:

There are three primary ways that sugars are found on plants (Lovell, 1926). Nectar is secreted from plant nectaries, either floral or extra-floral, and of great use to honeybees. Honeydew is sweet excrement of insects living on plants, and is typically of inferior quality to nectar and of less use to honeybees. Some plants also extrude a sweet substance that is known as sugars, with nearly the same composition as sap. Some beekeepers in Northern areas report that bees gather honeydew from insects or sugars from trees (especially Douglas Fir in Western Washington.) Because of the limited value, however, honeydew and tree sugars are not covered as important food forage for honeybees in this paper. Rather, information focuses on plant nectar and pollen.

Searching the Neighborhood for Forage:



How does a new beekeeper go about determining what forage is available in her neighborhood? There is the drive-around method where one can determine at least that forage as seen from the road.

To get a bees' eye view, one can use such technology as Google Earth to pinpoint a location and superimpose an imaginary boundary line that covers the possible bee flight area.

The Google map above shows the author's residence positioned in the center of the surrounding forage area. (Downloaded from Google Earth on March 30, 2011.)

Using Google Earth's tool to *search an address*, one can *add a ruler* (another tool) to indicate a distance of 2.5 miles (shown here as a red line) and then *superimpose the overlay option* to estimate the possible forage range for stationary hives (shown here as green box edges).

Using the overlay option as a guide, one can then travel around the area to determine potential forage plants, possible bloom times, and even potential threats to consider when determining where to place stationary hives. The checklists found at the end of this report can then be used for new beekeepers to check off plants found in their bee forage area.

The zoom option of the Google Earth program allows one to look more closely at areas within the forage range. It allowed the author to identify various small gardens and farms within forage distance, and then use the checklist of forage plants found in the end of this paper to inventory a 100+ acre natural wooded wetland adjacent to the property where her hives are kept.

Such information helps to build a sense of confidence about the forage available to one's bees. It also builds knowledge one can use to respond to others' questions about "what do your bees find to eat?" With such knowledge, it is easier to educate people who are interested in bees about the variety of native and cultivated plants that are good for bees, when those plants bloom, and how one can supplement for needed bee forage.

If forage is on cultivated farmland, one can correlate the forage area to landowner sites found on county land assessor maps. This way, a beekeeper can find and contact landowners about potential spraying (e.g. pesticides) that could harm the honeybees. It also is a way for beekeepers to begin conversations with nearby landowners about possibly adding bee forage if it is needed or not eradicating plants otherwise labeled as "noxious[1]" or invasive when they are found to be excellent bee forage plants.

Pollen and Nectar Plant Checklists:

The following two pages list pollen and nectar plants for East and West of the Cascade Mountains in Washington State. The checklists may be used by beekeepers to assess available forage for their hives. Plants are listed by their bloom time.

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[1] *The idea of a plant being "noxious" is a matter of perspective. What some county and university agriculture offices consider to be a "noxious" weed may be important bee forage. Such a case can be made for knotweed, knapweed, Boston and English ivy, purple loosestrife and other plants. So important are some of these plants as bee forage that another Master Beekeeper research paper will be proposed to cover the designation of such plants and ways to possibly expand the conversation about their usefulness.*

Pollen / Nectar Plant Check List
WEST of the Cascade Mountains, Washington

(List not inclusive of all pollen / nectar plants. Rather, it lists the most important.)

X	**Plant Name** ***Bold/Italic indicates very important forage for honeybees;*** * Indicates plant is considered to be noxious, but is important bee forage.	**Bloom Time**	**Nectar / Pollen (N/P)**	**Native / Introduced (N/I)**
	Filbert / Hazelnut	Jan – Mar	P	N/I
	Alder	Jan – June	N/P	N
	Manzanita	Feb – May	N/P	N
	Willow	Feb – Aug	P	N/I
	Mustards	Feb – Aug	N/P	I
	Currant – Wild	Mar – May	N/P	N
	Maple – Broadleaf / Vine	Mar – May	N/P	N
	Cottonwood	Mar – June	P, also Propolis	N
	Dandelion	Mar – Summer	N/P	N/I
	Elder	Mar – July	N/P	N
	Holly	Apr – May	N/P	N
	Oregon Grape	Apr – May	N/P	N
	Pear	Apr – May	N/P	I
	Apple	Apr – May/June	N/P	I
	Cherry	Apr – June	N/P	N/I
	Blueberry – Huckleberry	***Apr – June***	***N/P***	***N***
	Cascara sagrada (Bearberry)	Apr – June	N/P	N
	Honeysuckle	Apr - June	N/P	N/I
	Sunflower	Apr – July	N/P	N
	Brassica Family (in flower)	Apr – July	N/P	I
	****Blackberry***	***Apr – July***	***N/P***	***N***
	Raspberry	***Apr – July***	***N/P***	***N***
	Madrona	May	N/P	N
	Cranberry	May – June	N/P	N
	Hawthorn	May – June	N/P	N
	Locust – Black, Yellow	May – July	N/P	N
	Pine	May – July	P, also Propolis	N
	Snowberry / Indian Currant	***May – Aug***	***N/P***	***N***
	Bindweed (Morning Glory)	May – Aug	N/P	N/I
	Vetch	***May – Aug***	***N/P***	***N/I***
	Clover	***May – Oct***	***N/P***	***I***
	Buckwheat	May – Oct	N/P	N
	*Knotweed	May – Oct	N/P	I
	Fireweed	***June - Aug***	***N/P***	***N***
	Cucumber	June – Aug	N/P	N/I
	*Ivy, Boston	June - Sept	N/P	I
	Alfalfa	June - Sept	N/P	I
	Bird's Foot Trefoil	***June - Sept***	***N/P***	***I***
	****Knapweed (Star Thistle)***	***June - Oct***	***N/P***	***I***
	Corn	July – Aug	P	I
	Goldenrod	***July – Oct***	***N/P***	***N***
	Various culinary herbs if allowed to fully flower; thyme, oregano, lavender, marjoram, rosemary, mint, etc.	July – Oct	N/P	N/I
	*Ivy, English	Sept - Nov	N/P	I

Sources: Ayers and Harman, 2008, *The Hive and the Honey Bee*, Bee Forage of North America and the Potential for Planting for Bees, Dadant.
Burgett, Stringer and Johnston, 1989, Nectar and Pollen Plants of Oregon and the Pacific Northwest, Honeystone Press
NASA website: http://honeybeenet.gsfc.nasa.gov/Honeybees/ForageRegion.php; Downloaded March 1, 2011
Compiled by Franclyn Heinecke for WA State Master Beekeeper Research Paper, Pierce County Beekeepers Association, 2011

Pollen / Nectar Plant Check List

EAST of the Cascade Mountains, Washington

(List not inclusive of all pollen / nectar plants. Rather, it lists the most important.)

X	Plant Name ***Bold/Italic indicates very important forage for honeybees;*** * Indicates plant is considered to be noxious, but is important bee forage.	Bloom Time	Nectar / Pollen (N/P)	Native / Introduced (N/I)
	Willow	Jan – Aug	P	N/I
	Mustard	Feb – Aug	N/P	I
	Currant – Wild	***Mar – May***	***N/P***	***N***
	Maple	Mar – May	N/P	N
	Cottonwood	Mar – June	P, also Propolis	N
	Dandelion	Mar – Summer	N/P	N/I
	Apple	Mar – May/June	N/P	I
	Cherry	Mar – June	N/P	N/I
	Peach	Mar – June	N/P	N/I
	Pear	Mar – May	N/P	I
	Plum	Mar – June	N/P	N/I
	Holly	Apr – May	N/P	N
	Oregon Grape	Apr – May	N/P	N
	Blueberry – Huckleberry	Apr – June	N/P	N
	Honeysuckle	Apr - June	N/P	N/I
	Hawthorn	Apr – June	N/P	N
	Sunflower	Apr – July	N/P	N
	Brassica Family (in flower)	Apr – July	N/P	I
	****Blackberry***	***Apr – July***	***N/P***	***N***
	Locust – Black, Yellow	***Apr – July***	***N/P***	***N***
	Pine	Apr – July	P, also Propolis	N
	Snowberry / Indian Currant	Apr – Aug	N/P	N
	Clover	***Apr – Oct***	***N/P***	***I***
	Buckwheat	May – Oct	N/P	N
	*Knotweed	May – Oct	N/P	I
	Onion	May – July	N/P	I
	Radish	May – July	N/P	I
	Bird's Foot Trefoil	***May - Sept***	***N/P***	***I***
	****Knapweed (Star Thistle)***	***May - Oct***	***N/P***	***I***
	Parsley	Jun - July	N/P	I
	Carrot	Jun - Aug	N/P	I
	Lima Bean	July - Aug	N/P	I
	Fireweed	June - Aug	N/P	N
	Cucumber	June – Aug	N/P	N/I
	Alfalfa	***June - Sept***	***N/P***	***I***
	Mint	***June – Oct***	***N/P***	***I***
	Melons	Jun - Sep	N/P	I
	Pumpkins / Squash	Jun - Sep	N/P	I
	Corn	July – Aug	P	I
	Goldenrod	***July – Oct***	***N/P***	***N***
	Various culinary herbs if allowed to fully flower; thyme, oregano, lavender, marjoram, rosemary, mint, etc.	July – Oct	N/P	N/I

Sources: Ayers and Harman, 2008, *The Hive and the Honey Bee*, Bee Forage of North America and the Potential for Planting for Bees, Dadant.
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