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## Reestablishment of *Crataegus* Species Associated With Tennessee Gas Pipeline LLC's Northeast Upgrade Project Loop 323 in High Point State Park

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Prepared for CH2M

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## Reestablishment of *Crataegus* Species Associated With Tennessee Gas Pipeline LLC's Northeast Upgrade Project Loop 323 in High Point State Park

### Abstract

The Botany Department of the Morris Arboretum of the University of Pennsylvania was contracted by CH2M to provide, in as much as possible, identifications to species level of *Crataegus* (hawthorn) trees growing in proximity to the expanded natural gas pipeline right-of-way, designated Northeast Upgrade Project Loop 323 (NEUP Loop 323), through High Point State Park in Sussex County, New Jersey. In addition to species identification, seed collection was identified as a task to be completed in the initial phase of this project.

### Disciplines

Botany

### Comments

Prepared for CH2M

**Technical Report:**

**Specimen Identification and Seed Collection Tasks Associated with  
Project**

**Reestablishment of *Crataegus* species Associated with  
Tennessee Gas Pipeline LLC's Northeast Upgrade Project  
Loop 323 in High Point State Park**



**Prepared for CH2M by:**

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**January 20, 2016**



## **Introduction**

The Botany Department of the Morris Arboretum of the University of Pennsylvania was contracted by CH2M to provide, in as much as possible, identifications to species level of *Crataegus* (hawthorn) trees growing in proximity to the expanded natural gas pipeline right-of-way, designated Northeast Upgrade Project Loop 323 (NEUP Loop 323), through High Point State Park in Sussex County, New Jersey. In addition to species identification, seed collection was identified as a task to be completed in the initial phase of this project.

### **Physical characteristics of the site:**

The designated study site at High Point State Park is approximately 7.64 acres in size and lies along the natural gas pipeline for a distance of approximately 1,000 feet. The study area extends into the woods on either side of the pipeline opening a distance of approximately 100 feet, making the study area roughly rectangular (see Figure 1). The geographic centroid of the study site lies at 41.273146, -74.696461 degrees.

The bedrock geology of the study area is Bloomsburg Red Beds in approximately the western half and Shawangunk Formation in the eastern half (NJ DEP, 2007a). Surficial geology of the entire area is designated Kittatinny Mountain Till (NJ DEP, 2006a). Soil type of the study area is designated mainly Wurtsboro-Swartswood complex, 0% to 8% slopes, extremely stony with a small area at the western end designated Swartswood Loam, 8% to 15% slopes, extremely stony (USDA-NRCS, 2015).

The entire study site lies within the Big Flat Brook Watershed and Big Flat Brook, as well as a tributary stream, flow through the site (NJ DEP, 2002; 2006b). The eastern approximately two thirds of the site lies within the Sawmill Pond Swamp Natural Heritage Priority Site (NJ DEP, 2007b).

The wooded portion of the study area is covered by mid-successional red maple-dominated forest with canopy cover ranging from about 50 to 75 percent closure (but significantly less in patches). Abundant evidence of past anthropogenic disturbances in the form of stone walls, small excavations, and old refuse exist on the site. Examination of historic aerial photography (see figure 2) shows that a portion of the site was completely cleared of trees more than 80 years ago (ArcGIS Online, 2015).

### **Biological and taxonomic considerations:**

*Crataegus* is a genus of trees and shrubs most of whose species favor open, often somewhat disturbed habitats such as old fields, woods edges, roadsides, and rights-of-way. Most species are generalists with a few species known to prefer more specific habitat parameters, such as wetter or drier conditions, or higher or lower pH soils (Phipps, 2014). The species under consideration in this study are not among those with specific habitat requirements. While some *Crataegus* species are shade-tolerant, and may mature and reproduce under a dense forest canopy (Lance, 2014), the species noted in this report will typically persist in woodlands with incomplete canopy closure, but may not persist as canopy closure nears 100 percent.

A report from AECOM by Ball and Schall (2012) states the following: “At the intersection of Sawmill Road and the ROW, AECOM identified specimens of dotted hawthorn (*Crataegus punctata*) and Pennsylvania hawthorn (*C. pennsylvanica*) and made a tentative identification of Dodge's hawthorn (*C. dodgei*). This location was identified by the NJ NHP as a site where these species had been previously found. These three species are considered "species of concern" and afforded protection under the Highlands Water Protection and Planning Act.”

Ball and Schall (2012) cite Fernald (1950), Gleason and Cronquist (1991), and Rhoads and Block (2007) as references for their species descriptions. These three sources differ broadly in their taxonomic concept of many *Crataegus* species, including *C. pennsylvanica*, *C. holmesiana* and *C. dodgei*. Given the references cited, and their lack of indication of exactly which source they followed for the taxonomy, it is impossible to interpret exactly what they meant by the identifications included within their report.

Identification of species in the genus *Crataegus* is a difficult task because the taxonomy is often problematic. This is evidenced by the fact that, from study of many of the same specimens, C. S. Sargent considered the diversity of *Crataegus* in the northeastern U.S. to consist of more than 700 species (Macklin, 2001), while Arthur Cronquist considered only 22 species worthy of delimitation (Gleason and Cronquist, 1991).

Although several named hybrids have been reported from the Mid-Atlantic flora region, and such plants typically possess characters intermediate between the parent species, hybridization is now thought to be of limited significance in accounting for the taxonomic difficulties encountered in *Crataegus*. Rather, the presence of atypical or divergent forms coexistent with plants exhibiting typical morphology for any given species is believed to be a more general cause for confusion (Phipps, 2014). Many such atypical or divergent forms have been formally named (see for instance Ashe, 1902 and 1915, and Sargent, 1905).

## **Methods and Materials**

Multiple site visits were made to the designated study area at High Point State Park throughout the 2015 growing season in order to obtain as much material of the subject *Crataegus* species trees as possible.

All field and lab work on this project was carried out by Dr. Timothy A. Block and/or Dr. Cynthia Skema with assistance from Dr. Ann F. Rhoads, Ms. Emily Milbauer, and Ms. Michelle Mancini of the Botany Department staff. Keith D'Angiolillo or Suzann Collins from CH2M were present for all field operations and were of considerable help.

Once the study area was delimited with flagging tape we proceeded with locating, recording GPS locations for, and attaching numbered aluminum tags to each *Crataegus* tree within the study area that was at least two (2) meters in height and clearly a distinct individual. A total of 193 trees were tagged. Seedlings and sapling trees of less than two meters height were not considered in this study as such plants will not typically produce flowers and fruits necessary for

confident identification to species. Photographs were taken of all trees in all growth phases (see Appendix 2).

Available flowering material was collected in May, mature leaves of both short and long shoots in July, and available fruits in September. Fifty-five (55) of the study trees (28.5%) were collected in flower, and 34 (17.6%) were collected in fruit. Voucher specimens of flowering shoots and mature leaf shoots were pressed and dried in preparation for deposition in the herbarium at the Morris Arboretum (MOAR) as permanent documentation of this project.

Species determinations were made using dichotomous keys and species descriptions presented in the various works on *Crataegus* noted in the References section of this report (Fernald, 1950; Gleason and Cronquist, 1991; Haines, 2011; Lance, 2014; Macklin, 2001; Phipps, 2014; Rhoads and Block, 2007). Species determinations in this report follow the taxonomy of Phipps' treatment of *Crataegus* in volume 9 of Flora of North America (2014). Species identifications were further confirmed by comparing our collected material with herbarium specimens collected or annotated by Dr. James Phipps and/or Dr. James Macklin, both specialists in *Crataegus* taxonomy, housed at the Academy of Natural Sciences of Drexel University.

Taxonomically important characteristics of flowers, fruits, stems, and leaves were employed as suites of characters necessary to determine accurate species identifications (see Appendix 1 – technical species descriptions). All identification work was done in the Botany Department labs at the Morris Arboretum.

Seeds were extracted from the collected fruits by macerating the fruits with a rubber mallet and placing the macerated fruits in water for about a week. After the fruits had fermented and softened, the seeds were extracted by hand and placed in plastic dishes to dry thoroughly. The seeds were cleaned, counted, and placed in sealed plastic bags along with enough Perlite to cover them. These bags were then placed in the refrigerator for holding. At all steps of the process, each container and bag was labeled with both the tree tag number and the appropriate specimen collection number. The seeds can remain in this condition for a year or more without negatively impacting their ability to germinate.

## **Results and Discussion**

With the caveat and understanding that all taxonomic determinations represent scientific hypotheses which may be later confirmed or refuted, we have provided species determinations for all of the *Crataegus* study specimens from which a complete range of material (flowers, fruits, and mature leaves) could be collected. A summary of species determinations is presented in Table 1. Table 2 presents determinations by individual tree number.

Technical descriptions, including diagnostically important characters, of the species collected or noted in this report are presented in Appendix 1.

Table 1. Summary of species determinations with conservation status indicated

Species	Number of Specimens in Study	Global Rank (G-rank)*	NJ State Rank (S-rank)*	NJ State Status**
<i>Crataegus dodgei</i>	13	G4	S2	
<i>Crataegus holmesiana</i>	7	G5	S1	Endangered
<i>Crataegus macrosperma</i>	120	G5	S5	
<i>Crataegus pruinosa</i>	2	G5	S4	
<i>Crataegus punctata</i>	51	G5	S2	

\*G- and S-ranks are defined as follows: 1=critically imperiled, 2=imperiled, 3=vulnerable, 4=apparently secure, 5=secure (Natureserve, 2016)

\*\*Endangered (E) is defined by NJ DEP as a “native New Jersey plant species whose survival in the state or nation is in jeopardy” (NJ DEP, 2010).

Some *Crataegus* species, such as *C. punctata* and *C. dodgei*, are distinctive enough in vegetative condition to allow for confident determination to species. Those are so indicated in Table 2.

However, it is not possible to distinguish with confidence between sterile specimens (i.e., those without flowers or fruits) of *Crataegus macrosperma* (a common species) and *C. holmesiana* (a New Jersey endangered species). Furthermore, it is not possible to exclude the possibility of the presence of other vegetatively similar species from sterile specimens. Nonetheless, the individuals which never produced fruits or flowers, and conform to the shared vegetative morphology of *C. macrosperma* and *C. holmesiana*, are herein provisionally determined as *Crataegus macrosperma*, the generally more common of the two species. This hypothesis is put forth in response a stated desire to put a name on each specimen listed in Table 2, but is very tentative and only weakly supported by evidence from the collected specimens.

Most of the trees from which only sterile specimens were collected are either very young individuals or are situated in the shade of a canopy of taller trees, or both. Trees of the genus *Crataegus* typically do not produce flowers until they are several years old and provided with an amount of light typical of an opening or a forest edge. If they flower in future years, it may be possible to identify these specimens to species, especially those that now find themselves in habitat most suitable for *Crataegus*, e.g., on the edge of the expanded pipeline right-of-way.

Two specimens (2844 and 2849) are provisionally determined as *Crataegus pruinosa*, a common species, based on vegetative and flowering material. We would need to collect mature fruits from these trees to be certain of these identifications. No fruits were observed on either of these trees in the 2015 field season.

We concluded that *Crataegus pennsylvanica* was not present at the study site. *Crataegus pennsylvanica* is a very distinctive species even in a sterile condition. This species exhibits leaves which are densely pubescent when young (see Appendix 1 – Figure 3), persistently pubescent along the veins on the abaxial surface even in maturity, and leaf blades which average 6 to 10 centimeters in length (Phipps, 2014). None of the specimens collected or observed during this study exhibit the above suite of characters.



Table 2. List of trees examined and species determinations.

Tree number	Species	Collected in flower	Collected in fruit
2801	<i>Crataegus macrosperma</i> *	No	No
2802	<i>Crataegus macrosperma</i>	Yes	Yes
2803	<i>Crataegus macrosperma</i> *	No	No
2804	<i>Crataegus macrosperma</i> *	No	No
2805	<i>Crataegus macrosperma</i> *	No	No
2806	<i>Crataegus macrosperma</i> *	No	No
2807	<i>Crataegus macrosperma</i> *	No	No
2808	<i>Crataegus macrosperma</i>	Yes	No
2809	<i>Crataegus macrosperma</i>	Yes	No
2810	<i>Crataegus macrosperma</i> *	No	No
2811	<i>Crataegus macrosperma</i> *	No	No
2812	<i>Crataegus punctata</i>	No	No
2813	<i>Crataegus punctata</i>	Yes	No
2814	<i>Crataegus macrosperma</i> *	No	No
2815	<i>Crataegus macrosperma</i> *	No	No
2816	<i>Crataegus macrosperma</i> *	No	No
2817	<i>Crataegus macrosperma</i> *	No	No
2818	<i>Crataegus macrosperma</i> *	No	No
2819	<i>Crataegus punctata</i>	No	No
2820	<i>Crataegus holmesiana</i>	Yes	No
2821	<i>Crataegus punctata</i>	No	No
2822	<i>Crataegus macrosperma</i>	Yes	Yes
2823	<i>Crataegus punctata</i>	Yes	Yes
2824	<i>Crataegus punctata</i>	No	No
2825	<i>Crataegus punctata</i>	Yes	Yes
2826	<i>Crataegus punctata</i>	Yes	Yes
2827	<i>Crataegus dodgei</i>	Yes	Yes
2828	<i>Crataegus macrosperma</i>	Yes	No
2829	<i>Crataegus holmesiana</i>	Yes	No
2830	<i>Crataegus macrosperma</i> *	No	No
2831	<i>Crataegus punctata</i>	No	No
2832	<i>Crataegus punctata</i>	Yes	Yes
2833	<i>Crataegus punctata</i>	No	No
2834	<i>Crataegus punctata</i>	Yes	No
2835	<i>Crataegus punctata</i>	Yes	Yes
2836	<i>Crataegus dodgei</i>	Yes	Yes
2837	<i>Crataegus dodgei</i>	Yes	No
2838	<i>Crataegus punctata</i>	Yes	Yes
2839	<i>Crataegus holmesiana</i>	Yes	Yes

2840	<i>Crataegus macrosperma*</i>	No	No
2841	<i>Crataegus dodgei</i>	Yes	Yes
2842	<i>Crataegus dodgei</i>	Yes	Yes
2843	<i>Crataegus dodgei</i>	Yes	Yes
2844	<i>Crataegus pruinosa*</i>	Yes	No
2845	<i>Crataegus punctata</i>	No	No
2846	<i>Crataegus punctata</i>	No	No
2847	<i>Crataegus punctata</i>	No	No
2848	<i>Crataegus punctata</i>	No	No
2849	<i>Crataegus pruinosa*</i>	Yes	No
2850	<i>Crataegus punctata</i>	No	No
2851	<i>Crataegus punctata</i>	Yes	No
2852	<i>Crataegus punctata</i>	No	No
2853	<i>Crataegus punctata</i>	No	No
2854	<i>Crataegus macrosperma*</i>	No	No
2855	<i>Crataegus punctata</i>	No	No
2856	<i>Crataegus macrosperma*</i>	No	No
2857	<i>Crataegus macrosperma*</i>	No	No
2858	<i>Crataegus macrosperma*</i>	No	No
2859	<i>Crataegus macrosperma*</i>	No	No
2860	<i>Crataegus macrosperma*</i>	No	No
2861	<i>Crataegus macrosperma*</i>	No	No
2862	<i>Crataegus macrosperma*</i>	No	No
2863	<i>Crataegus macrosperma*</i>	No	No
2864	<i>Crataegus macrosperma*</i>	No	No
2865	<i>Crataegus macrosperma*</i>	No	No
2866	<i>Crataegus macrosperma*</i>	No	No
2867	<i>Crataegus macrosperma*</i>	No	No
2868	<i>Crataegus macrosperma*</i>	No	No
2869	<i>Crataegus macrosperma*</i>	No	No
2870	<i>Crataegus punctata</i>	No	No
2871	<i>Crataegus punctata</i>	No	No
2872	<i>Crataegus macrosperma</i>	Yes	Yes
2873	<i>Crataegus macrosperma*</i>	No	No
2874	<i>Crataegus punctata</i>	Yes	Yes
2875	<i>Crataegus punctata</i>	Yes	Yes
2876	<i>Crataegus punctata</i>	Yes	No
2877	<i>Crataegus dodgei</i>	Yes	Yes
2878	<i>Crataegus punctata</i>	Yes	No
2879	<i>Crataegus punctata</i>	Yes	Yes
2880	<i>Crataegus dodgei</i>	Yes	Yes

2881	<i>Crataegus punctata</i>	Yes	Yes
2882	<i>Crataegus macrosperma*</i>	No	No
2883	<i>Crataegus punctata</i>	Yes	Yes
2884	<i>Crataegus macrosperma*</i>	No	No
2885	<i>Crataegus macrosperma*</i>	No	No
2886	<i>Crataegus holmesiana</i>	Yes	No
2887	<i>Crataegus holmesiana</i>	Yes	No
2888	<i>Crataegus macrosperma*</i>	No	No
2889	<i>Crataegus macrosperma*</i>	No	No
2890	<i>Crataegus macrosperma*</i>	No	No
2891	<i>Crataegus macrosperma*</i>	No	No
2892	<i>Crataegus macrosperma*</i>	No	No
2893	<i>Crataegus holmesiana</i>	Yes	Yes
2894	<i>Crataegus punctata</i>	No	No
2895	<i>Crataegus punctata</i>	Yes	Yes
2896	<i>Crataegus dodgei</i>	Yes	Yes
2897	<i>Crataegus dodgei</i>	Yes	Yes
2898	<i>Crataegus punctata</i>	Yes	Yes
2899	<i>Crataegus holmesiana</i>	Yes	Yes
2900	<i>Crataegus punctata</i>	Yes	Yes
2907	<i>Crataegus dodgei</i>	No	No
2908	<i>Crataegus macrosperma*</i>	No	No
2909	<i>Crataegus dodgei</i>	Yes	No
2910	<i>Crataegus punctata</i>	Yes	No
2911	<i>Crataegus punctata</i>	No	No
2912	<i>Crataegus punctata</i>	No	No
2913	<i>Crataegus punctata</i>	No	No
2914	<i>Crataegus punctata</i>	No	No
2915	<i>Crataegus punctata</i>	Yes	Yes
2916	<i>Crataegus punctata</i>	Yes	No
2917	<i>Crataegus punctata</i>	No	No
2918	<i>Crataegus punctata</i>	No	No
2919	<i>Crataegus punctata</i>	Yes	Yes
2920	<i>Crataegus macrosperma*</i>	No	No
2921	<i>Crataegus punctata</i>	No	No
2922	<i>Crataegus macrosperma*</i>	No	No
2923	<i>Crataegus macrosperma*</i>	No	No
2924	<i>Crataegus macrosperma*</i>	No	No
2925	<i>Crataegus macrosperma*</i>	No	No
2926	<i>Crataegus macrosperma*</i>	No	No
2927	<i>Crataegus macrosperma*</i>	No	No

2928	<i>Crataegus macrosperma*</i>	No	No
2929	<i>Crataegus macrosperma*</i>	No	No
2930	<i>Crataegus macrosperma*</i>	No	No
2932	<i>Crataegus macrosperma*</i>	No	No
2933	<i>Crataegus dodgei</i>	No	No
2934	<i>Crataegus macrosperma*</i>	No	No
2935	<i>Crataegus macrosperma*</i>	No	No
2936	<i>Crataegus macrosperma*</i>	No	No
2937	<i>Crataegus macrosperma*</i>	No	No
2938	<i>Crataegus macrosperma*</i>	No	No
2939	<i>Crataegus punctata</i>	Yes	Yes
2940	<i>Crataegus punctata</i>	No	No
2941	<i>Crataegus macrosperma*</i>	No	No
2942	<i>Crataegus macrosperma*</i>	No	No
2943	<i>Crataegus macrosperma*</i>	No	No
2944	<i>Crataegus macrosperma*</i>	No	No
2945	<i>Crataegus macrosperma*</i>	No	No
2946	<i>Crataegus macrosperma*</i>	No	No
2947	<i>Crataegus macrosperma*</i>	No	No
2948	<i>Crataegus macrosperma*</i>	No	No
2949	<i>Crataegus macrosperma*</i>	No	No
2950	<i>Crataegus macrosperma*</i>	No	No
2951	<i>Crataegus macrosperma*</i>	No	No
2952	<i>Crataegus macrosperma*</i>	No	No
2953	<i>Crataegus macrosperma*</i>	No	No
2954	<i>Crataegus macrosperma*</i>	No	No
2955	<i>Crataegus macrosperma*</i>	No	No
2956	<i>Crataegus macrosperma*</i>	No	No
2957	<i>Crataegus macrosperma*</i>	No	No
2958	<i>Crataegus macrosperma*</i>	No	No
2959	<i>Crataegus macrosperma*</i>	No	No
2960	<i>Crataegus macrosperma*</i>	No	No
2961	<i>Crataegus macrosperma*</i>	No	No
2962	<i>Crataegus macrosperma*</i>	No	No
2963	<i>Crataegus macrosperma*</i>	No	No
2964	<i>Crataegus macrosperma*</i>	No	No
2965	<i>Crataegus macrosperma*</i>	No	No
2966	<i>Crataegus macrosperma*</i>	No	No
2967	<i>Crataegus macrosperma*</i>	No	No
2968	<i>Crataegus macrosperma*</i>	No	No
2969	<i>Crataegus macrosperma*</i>	No	No

2970	<i>Crataegus macrosperma</i> *	No	No
2971	<i>Crataegus macrosperma</i> *	No	No
2972	<i>Crataegus macrosperma</i> *	No	No
2973	<i>Crataegus macrosperma</i> *	No	No
2974	<i>Crataegus macrosperma</i> *	No	No
2975	<i>Crataegus macrosperma</i> *	No	No
2976	<i>Crataegus macrosperma</i> *	No	No
2977	<i>Crataegus macrosperma</i> *	No	No
2978	<i>Crataegus macrosperma</i> *	No	No
2979	<i>Crataegus macrosperma</i> *	No	No
2980	<i>Crataegus macrosperma</i>	Yes	No
2981	<i>Crataegus macrosperma</i> *	No	No
2982	<i>Crataegus macrosperma</i> *	No	No
2983	<i>Crataegus macrosperma</i> *	No	No
2984	<i>Crataegus macrosperma</i> *	No	No
2985	<i>Crataegus macrosperma</i> *	No	No
2986	<i>Crataegus macrosperma</i> *	No	No
2987	<i>Crataegus macrosperma</i> *	No	No
2988	<i>Crataegus macrosperma</i> *	No	No
2989	<i>Crataegus macrosperma</i> *	No	No
2990	<i>Crataegus macrosperma</i> *	No	No
2991	<i>Crataegus macrosperma</i> *	No	No
2992	<i>Crataegus macrosperma</i> *	No	No
2993	<i>Crataegus macrosperma</i>	Yes	No
2994	<i>Crataegus punctata</i>	Yes	Yes
2995	<i>Crataegus punctata</i>	Yes	Yes
2996	<i>Crataegus macrosperma</i> *	No	No
2997	<i>Crataegus macrosperma</i>	Yes	No
2998	<i>Crataegus macrosperma</i> *	No	No
2999	<i>Crataegus macrosperma</i> *	No	No
3000	<i>Crataegus macrosperma</i> *	No	No

\*Specimen provisionally determined based on taxonomically incomplete material

Note that tree number 2920 was cut at ground level by a beaver sometime between our May and July site visits. Trees numbered 2887, 2891, 2892, 2893, and 2921 were cut to about 2 feet above the ground in an apparent roadside vegetation management effort along Sawmill Road sometime between our July and September site visits. All of these trees, although severely damaged, may regrow from their bases, but are effectively eliminated from further study.

Table 3 is a summary of seeds collected by species, while Table 4 presents the counts of seeds (nutlets) by tree specimen obtained from the fruits collected in September 2015. These seeds are currently in storage at the Morris Arboretum awaiting the propagation process.

Table 3. Summary of seeds collected by species.

Species	Number of Seeds Collected
<i>Crataegus dodgei</i>	716
<i>Crataegus holmesiana</i>	14
<i>Crataegus macrosperma</i>	77
<i>Crataegus pruinosa</i>	0
<i>Crataegus punctata</i>	1011
Total	1818

Table 4. List of trees from which seeds were collected.

Tree number	Species	Number of seeds obtained
2802	<i>Crataegus macrosperma</i>	31
2822	<i>Crataegus macrosperma</i>	3
2823	<i>Crataegus punctata</i>	7
2825	<i>Crataegus punctata</i>	3
2826	<i>Crataegus punctata</i>	45
2827	<i>Crataegus dodgei</i>	92
2832	<i>Crataegus punctata</i>	5
2835	<i>Crataegus punctata</i>	122
2836	<i>Crataegus dodgei</i>	66
2838	<i>Crataegus punctata</i>	41
2839	<i>Crataegus holmesiana</i>	8
2841	<i>Crataegus dodgei</i>	75
2842	<i>Crataegus dodgei</i>	166
2843	<i>Crataegus dodgei</i>	67
2872	<i>Crataegus macrosperma</i>	43
2874	<i>Crataegus punctata</i>	153
2875	<i>Crataegus punctata</i>	76
2877	<i>Crataegus dodgei</i>	12
2879	<i>Crataegus punctata</i>	73
2880	<i>Crataegus dodgei</i>	5
2881	<i>Crataegus punctata</i>	40
2883	<i>Crataegus punctata</i>	245
2893	<i>Crataegus holmesiana</i>	3
2895	<i>Crataegus punctata</i>	64
2896	<i>Crataegus dodgei</i>	175
2897	<i>Crataegus dodgei</i>	58
2898	<i>Crataegus punctata</i>	7
2899	<i>Crataegus holmesiana</i>	3
2900	<i>Crataegus punctata</i>	48

Tree number	Species	Number of seeds obtained
2915	<i>Crataegus punctata</i>	50
2919	<i>Crataegus punctata</i>	12
2939	<i>Crataegus punctata</i>	6
2994	<i>Crataegus punctata</i>	6
2995	<i>Crataegus punctata</i>	8

Seeds of *Crataegus* species are reported to exhibit a biological phenomenon variously referred to as double dormancy, deep dormancy, or embryo dormancy, meaning that they require complex treatment prior to germination. This treatment typically includes an extended period of warm stratification followed by an extended period of cold stratification. It is not unusual under natural conditions for it to take two years or more for *Crataegus* seeds to germinate (USDA Forest Service, 1974). Very little scientific literature exists which addresses the germination requirements/success of individual hawthorn species. However, *Seeds of Woody Plants in the United States* (cited above) notes that *C. punctata* seeds warm stratified for 120 days followed by cold stratification for 135 days resulted in a 60% germination rate. We were unable to find such specific information regarding germination rates for the other species collected in this study.

The *Crataegus* trees earlier removed from the study site and transferred to the Williams Nursery site in Lycoming County, PA were not included in the body of this study. These trees were tagged with numbered tags (400s) and a few specimens were collected, however, not enough material was obtainable from these trees to allow for confident species identifications at this point. A total of 49 trees were tagged, 33 of which were apparently dead, and 16 were observed to be in poor health at best. It seems unlikely that these trees will be healthy enough to be moved back to the study site for a number of years, if ever. However, we are able to conclude that none of the trees at Williams are *C. dodgei*, *C. pennsylvanica*, or *C. punctata* based on vegetative characters. The 16 living trees stored at the Williams facility are provisionally determined to be *Crataegus macrosperma* primarily based on flower characters from eight collected specimens.

The smaller *Crataegus* trees already transplanted to the right-of-way were tagged with numbered tags (500s) as well. Of the 72 small trees tagged in this set two (2) were apparently dead, and another 19 appeared to be in very poor condition. No material was collected from these specimens as, in our judgement, collecting from these small individuals would jeopardize their long-term survivability. Obviously, no attempt to identify these individuals to species could be made this year.

All voucher specimens will be stored in the herbarium at the Morris Arboretum (MOAR) and will be made available for examination upon request. All quantitative and qualitative data collected and/or created, as well as all photographs taken in the course of this study are maintained at the Morris Arboretum as well.

Figure 1 shows the locations of each specimen tree, as determined by GPS, included in this study with indications of whether each tree was collected in vegetative only condition, in flower, or in fruit.

It is very interesting that the area just east of Sawmill Road on the north side of the pipeline right-of-way that shows the greatest concentration of older, more fertile *Crataegus* trees corresponds almost precisely with an opening in the woodland cover shown on historic aerial photography (ArcGIS Online, 2015) from 1930 (figure 2). This prior opening would, in part, explain the presence of a small, but unusually diverse, patch of hawthorn species at this site. Further examination of this part of the study site could provide valuable data to help inform a larger conservation plan for the site.



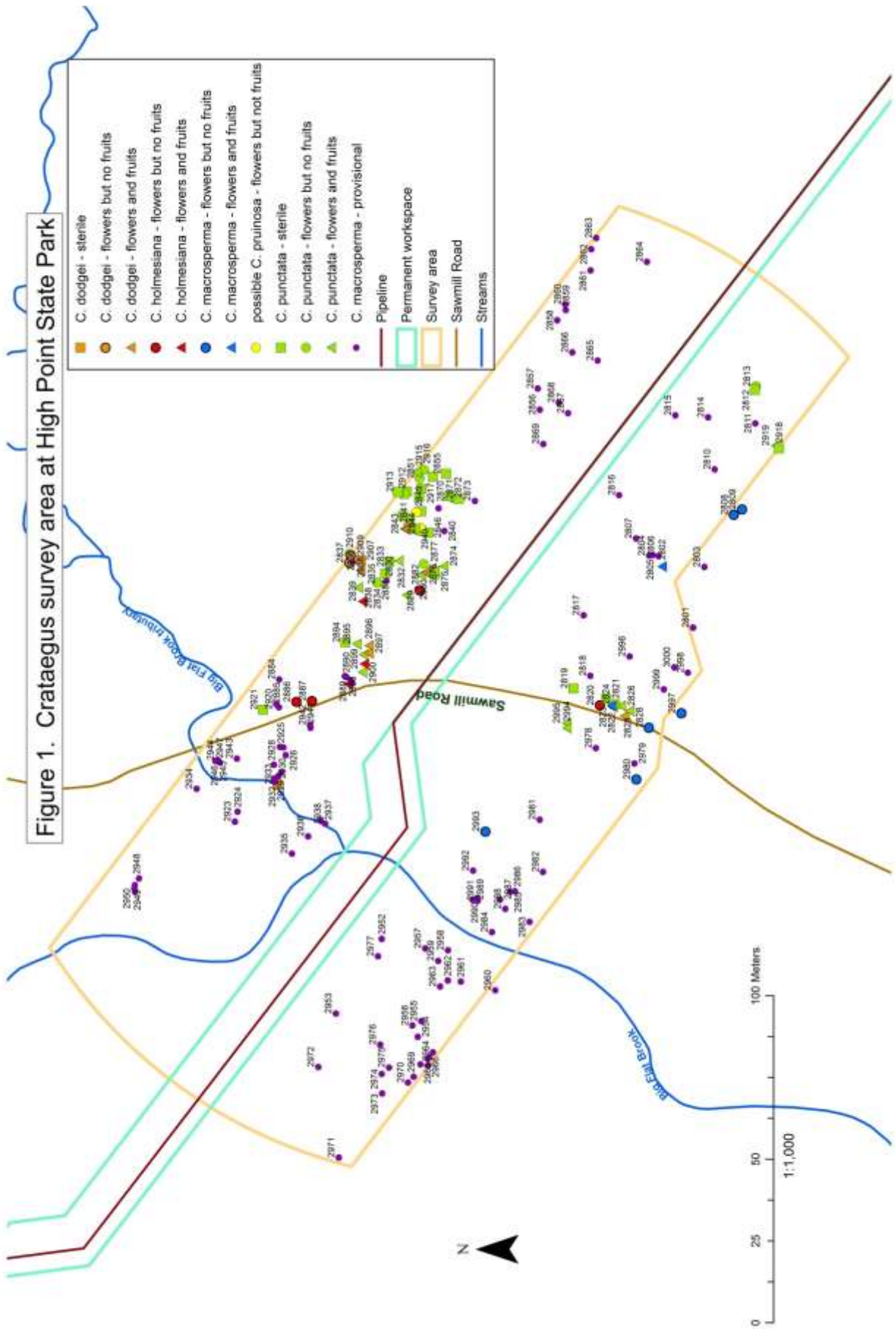
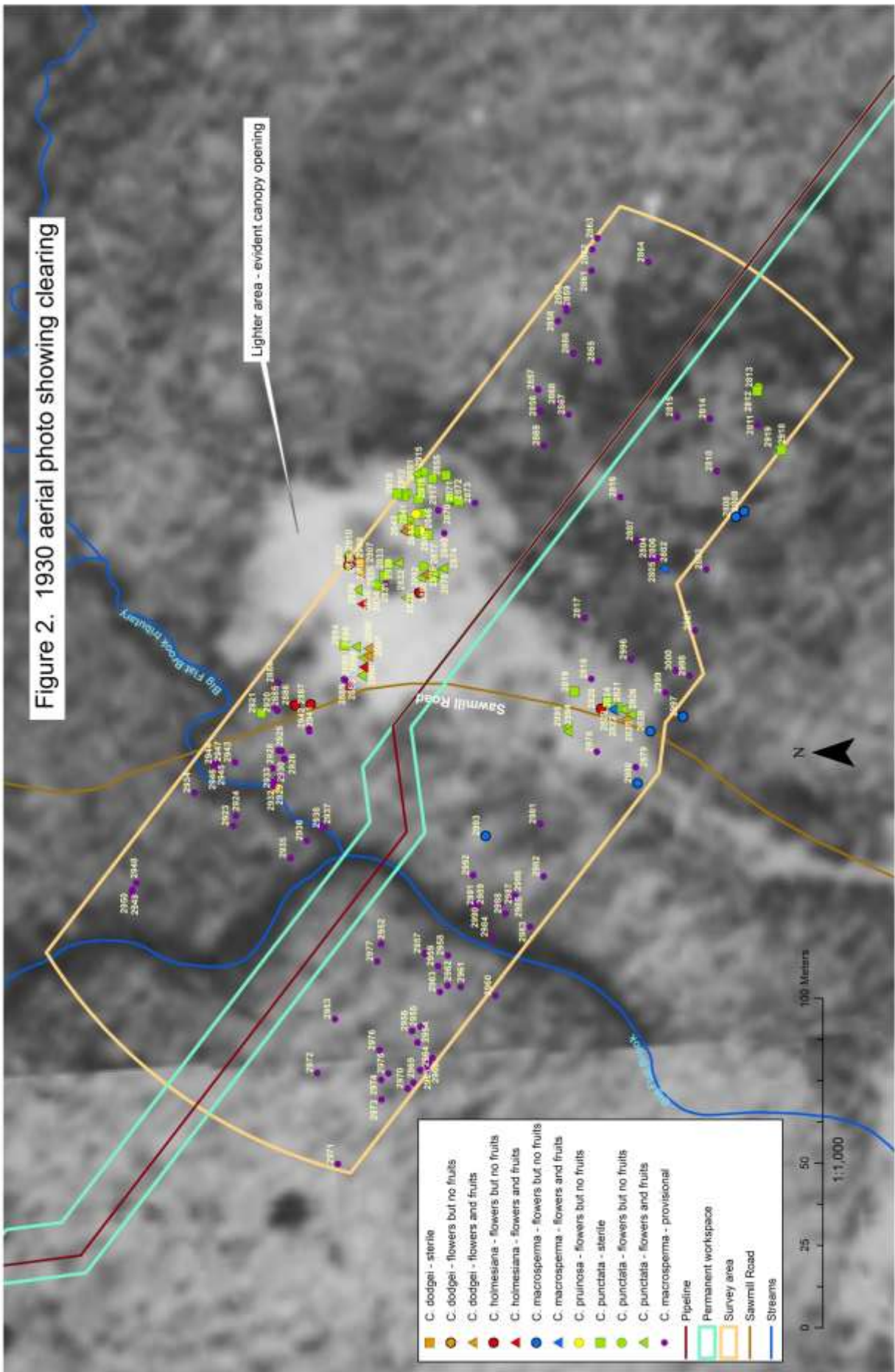


Figure 2. 1930 aerial photo showing clearing



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Appendix 1 – Technical species descriptions (modified from Phipps, 2014)

*Crataegus dodgei* Ashe

Shrubs or trees to about 50 dm tall; first-year twigs gray-brown, glabrous, older dull gray; thorns slender, straight to recurved, 3 to 7 cm long, often abundant; petioles generally glabrous, sometimes glandular; leaf blade suborbiculate to generally rhombic to broadly elliptic, rounded to cuneate at base, lobes 0 to 4 per side and shallow, margins generally crenate to crenate-serrate; veins 4 to 6 per side; flowers about 15 mm in diameter, hypanthium more or less glabrous; sepals entire to more or less glandular-toothed; stamens 10, anthers ivory; fruits suborbicular, about 10 mm in diameter, usually greenish to yellowish; nutlets 2 to 3 per fruit.

*Crataegus holmesiana* Ashe

Shrubs or trees to about 70 dm tall, often single-trunked; first-year twigs green to reddish, usually glabrous to sparsely pubescent; thorns slender, usually recurved, 3 to 6 cm long; petioles usually somewhat pubescent, often sparsely glandular; leaf blade ovate to narrowly ovate, cuneate to rounded at base; flowers about 15 mm in diameter, hypanthium usually pubescent; sepals glandular-serate to –laciniate; stamens 5 to 10, anthers pink to rose-purple; fruits usually bright to deep red, more or less ellipsoid; nutlets 3 to 5 per fruit.

*Crataegus macrosperma* Ashe

Shrubs or trees to about 70 dm tall, usually multi-stemmed; first-year twigs greenish to reddish, more or less glabrous; thorns stout to slender, 2 to 6 cm long; petioles usually bearing some sessile glands; leaf blade more or less ovate, 3 to 9 cm long, subcordate to rounded or cuneate at base, shallowly to deeply lobed, 4 to 7 veins per side, adaxially scabrous-pubescent when young, more or less glabrous older; flowers about 15 mm in diameter, hypanthium glabrous; sepals about 5 mm long, margins generally entire to shallowly toothed; stamens 5 to 10, anthers pink to purple; fruits suborbicular to elliptic, 8 to 15 mm in diameter, usually bright to deep red; nutlets 3 to 5 per fruit.

*Crataegus pennsylvanica* Ashe

Shrubs or trees to 80 dm tall; first-year twigs light brown, densely pubescent, older twigs gray; thorns usually few or absent; petioles densely pubescent young (see figure 3) and sparsely so older, often with some stipitate glands; leaf blade broadly ovate to ovate-deltate, 6 to 10 cm long, broadly cuneate to truncate at base, 4 to 6 shallow lobes per side, veins usually 5 to 7 per side, abaxially densely pubescent when young, sparsely so when older, adaxially densely appressed scabrous when young; flowers 17 to 21 mm in diameter, hypanthium densely tomentose; sepals about 8 mm long with glandular-laciniate margins; stamens usually 5 or 10, anthers cream to pale pink or salmon-colored; fruits suborbicular, 10 to 12 mm in diameter, bright red; nutlets 4 or 5 per fruit.



Figure 3. *Crataegus pennsylvanica* specimen showing dense pubescence on twigs, petioles, peduncle, and fruit. (From MOAR specimen collected by Ann F. Rhoads and Timothy A. Block; May 23, 2001; Cobbs Creek Park, Philadelphia County, PA)

*Crataegus pruinosa* (H.L. Wendland) K. Koch

Shrubs or trees to about 70 dm tall; first-year twigs dull purple-brown, older gray; thorns slender, 3 to 5 cm long; petioles usually sparsely glandular; leaf blade ovate to ovate-oblong to deltate, lobes 2 to 4 per side, adaxially glabrous to sparsely pubescent especially along the veins; flowers about 15 mm in diameter; sepals about 5 mm long, margins usually entire to subentire; stamens 20, anthers usually pale pink; fruit usually greenish with reddish patches, about 15 mm in diameter; nutlets 3 to 5 per fruit.

*Crataegus punctata* Jacquin

Shrubs or trees to 80 dm tall; first-year twigs pale gray; thorns usually numerous, slender, 2 to 5 cm long; petioles winged near base of leaf blade, usually eglandular; leaf blade narrowly obovate to oblanceolate to broadly elliptic, narrowly cuneate at base, often unlobed or with 5 to 7 shallow lobes per side, veins usually 7 to 10 per side, abaxial surface generally sparsely pilose when young, adaxial surface dull (not shiny); flowers 14 to 19 mm in diameter, hypanthium pubescent; sepals about 7 mm long, adaxially pubescent; stamens usually 20, anthers cream to pink-purple; fruits suborbicular, yellowish to scarlet or deep burgundy; nutlets 3 to 5 per fruit.

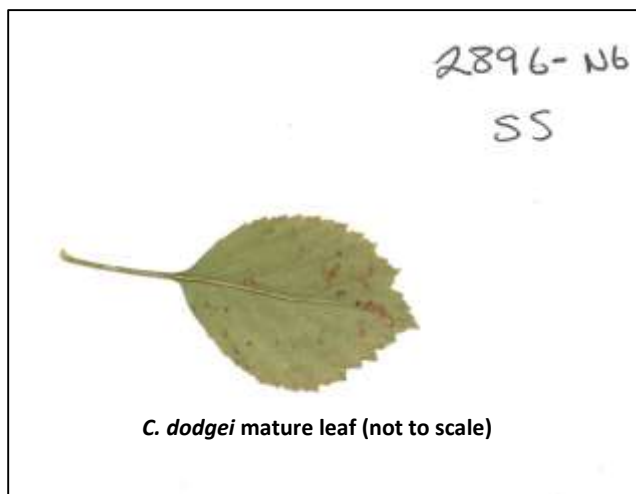
Appendix 2 – Selected photographs



*Crataegus dodgei* flowers & young leaves



*Crataegus dodgei* mature fruits



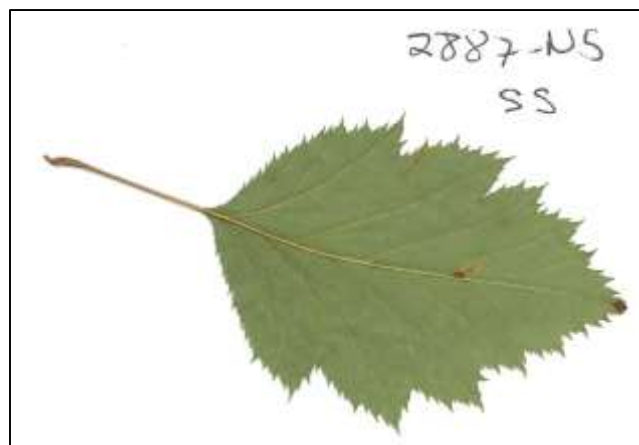
*C. dodgei* mature leaf (not to scale)



*Crataegus holmesiana* flowers & young leaves



*C. holmesiana* mature fruits



*C. holmesiana* mature leaf (not to scale)

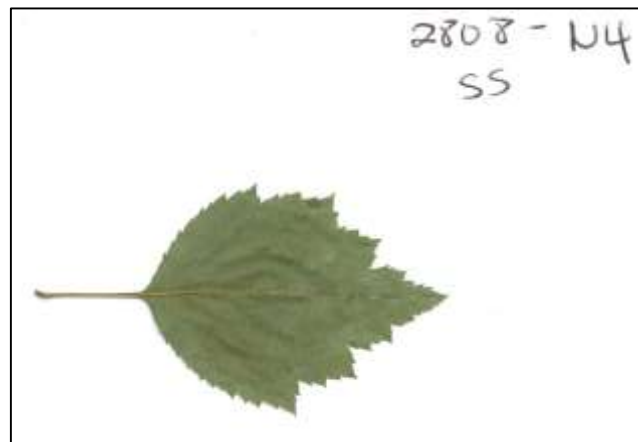




*Crataegus macrosperma* buds and young leaves



*C. macrosperma* mature fruits



*C. macrosperma* mature leaf (not to scale)



*Crataegus punctata* flower and young leaves



*C. punctata* mature fruits



*C. punctata* mature leaf (not to scale)