

October 29, 2008

**USA-NPN Species Protocols Working Group
Meeting Summary**

October 9 and 10 (half-day), 2008

**National Coordinating Office
University of Arizona
Tucson, Arizona**

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Overview

In attendance: Kathryn Thomas (presiding), Jake Weltzin (Thursday), Paul Alaback, Lisa Benton (Thursday morning), Ellen Denny, Brian Haggerty, Sandra Henderson, Abe Miller-Rushing

Purpose of meeting: The reason for the SPWG subgroup meeting was to determine how to integrate the phenophase events selected and defined by Project Bud Burst (PBB) and those of the core and intensive phenophase events selected and defined by the NPN NCO. The meeting was sponsored by the National Science Foundation Research Coordinating Network grant #0639794 through Dr. Mark Schwartz.

Four meeting goals were established:

- 1) Develop a plan for integration of PBB and NPN PPP core protocols in time for 2009 monitoring season
- 2) Discuss/develop recommendations for integration of additional plant phenology monitoring efforts into PBB/NPN; UCSB as a case study
- 3) Discuss how plant species are added to PBB and NPN PPP
- 4) Discuss strategies for training and website presentation that promotes smooth integration across PBB and NPN

Outcomes:

Goal 1) The subgroup reviewed and discussed phenophase events and their definitions for six groups of plant species: deciduous trees/shrubs, wind pollinated; deciduous trees/shrubs non-wind pollinated; broadleaf evergreen; conifer (primarily needle-leaf evergreen); herbaceous broadleaf; and grass. The subgroup mutually agreed upon the phenophase events and definitions presented in the Appendix A spreadsheet¹. They agreed that PBB represented the 'basic' phenophase events and the additional 'core' and 'intensive' phenophase events represent a progression of complexity and time it takes to monitor each phenophase event. There was substantial agreement upon completion of this spreadsheet toward the selection of the basic (PBB), core (NCO), and intensive (NCO) phenophase events.

Late in the meeting a proposal was made toward restructuring of the presentation of phenophase events in data collection instructions and datasheet organization. The 'champions' of this proposal (Denny, Haggerty, Miller-Rushing) believe this restructuring of data recording is propitious toward solving difficulties that have been encountered and are expected to be encountered in developing effective monitoring protocols for plants with multiple flowering and leaving cycles in a single year (drought adapted, subtropical, and tropical species). The proposal was not discussed in the meeting by the full group and has issues for data entry cyberinfrastructure, database architecture, and database compatibility within the current NPN

¹ Appendix A shows in gray highlight all phenophase events were have been added, changed, or deleted by the SPWG subgroup. An explanation for each action occurs in the last column 'Notes' Text in red was added during the SPWG review of the meeting notes and indicate additional changes proposed since the meeting.

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central database and with the PBB database. The champions of the proposal have developed supplemental materials that describe the basic concepts of the proposal and these are included in this document. Appendix B1 presents a (first draft) of the rationale for proposal. Appendix BC presents two versions of how field observations would be recorded, both annotated.

Post meeting follow up note: Sandra Henderson, Paul Alaback, and Jake Weltzin have each expressed to K. Thomas that the proposal has merit but its development and implementation are not trivial and is not feasible for the 2/15/09 date for PBB and most probably not for the NCO operations. The integration of the animal phenology data into the database is also a concern.

Goal 2) The subgroup agreed that PBB basic phenophase events serve as the 'net' to capture all new observers that cannot (for whatever reason) begin with core phenophase events. In addition, PBB allows observations to be made for plant species that are not either the PBB or NCO lists. Monitoring programs that are 'special' are currently being considered on a case-by-case basis by the NCO.

Goal 3) Sandra Henderson handed out spreadsheets that summarized the raw monitoring input for PBB in 2008. In addition to species that were previously identified as PBB species, monitoring observations were submitted for numerous other species. The subgroup agreed that K. Thomas would develop draft criteria for inclusion of addition of new species into the list of regional-focal species. Also, a summary of all species – PBB, clonal, calibration, and regional-focal – will be prepared for evaluation before the 2009 monitoring 'start-date'. The initial listing of species was developed without representation from all regions of the U.S. There e will probably be a significant number of valid requests to add new species as regional representatives join the NPN.

Goal 4) A number of points were made, although not discussed in great length by the subgroup:

- Regarding the web 'bubble' graphic illustrating NPN partners. The subgroup noted the advantages of graphically separating types of NPN partners from types of NCO coordinated products.
- Some group members suggested the rationale for the phenophase events selected be presented on the NPN web pages.
- The distinction between the NPN and NCO was discussed. A draft description of the Plant Phenology Program in relationship to the NCO and NPN was presented as one view of the relationship of NCO programs with the wider NPN (see Appendix D).

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Appendix A.1 Phenophase Definitions: Deciduous Trees/Shrubs Wind Pollinated

PBB	Core	Intensive	BBCH code	Definition	Notes
	Leaf budburst	Leaf budburst	9	In at least 3 locations on the plant, a leaf bud shows green tips.	Add phenophase BBCH 9, added definition
First leaves unfolded	First leaves unfolded	First leaves unfolded	11	In at least 3 locations on the plant, a young leaf has completely unfolded from the bud so that the petiole (leaf stalk) or leaf base is visible. The leaf may need to be bent backwards to see the petiole stalk or leaf base.	Change first leaf to first leaves unfolded, change leaf to leaves, BBCH changed from 10a to 11, change definition
All leaves unfolded	All leaves unfolded	All leaves unfolded	19	For the whole plant, virtually all (95-100%) of the young leaves have completely unfolded from the bud so that the leaf stalk or leaf base is visible.	New phenophase and definition, BBCH 19
		25% of full leaf size elongation	43	The majority of young leaves have unfolded completely and have expanded elongated to one-quarter (25%) of their mature size. Leaf elongation size may also be estimated by viewing the canopy as a whole. At 25% of full leaf size elongation , the canopy appears to be approximately one-quarter (25%) full.	
		50% of full leaf size elongation	45	The majority of young leaves have unfolded completely and have expanded elongated to half (50%) of their mature size. Leaf elongation size may also be estimated by viewing the canopy as a whole. At 50% of full leaf size elongation , the canopy appears to be approximately one-half (50%) full.	
	75% of full leaf size elongation	75% of full leaf size elongation	47	The majority of young leaves have unfolded completely and have expanded elongated to three-quarters (75%) of their mature size. Leaf elongation size may also be estimated by viewing the canopy as a whole. At 75% of full leaf size elongation , the canopy appears to be approximately three-quarters (75%) full.	The rationale for this phenophase event in particular should be described.

		Full leaf size elongation	49	The majority of young leaves have unfolded completely and have expanded elongated to 95-100% of their mature size. At full leaf size elongation, the canopy appears to have reached its full density.	
First pollen	First pollen	First pollen	60	In at least 3 locations on the plant, pollen is released from an inflorescence when gently shaken or blown.	Add First pollen to Core, dropped released, altered definition
Full pollen	Full pollen	Full pollen	65	For the whole plant, half (50%) of the inflorescences release pollen when gently shaken or blown.	Added phenophase event and definition.
	End of pollen	End of pollen	69	The last visible inflorescence has begun to wither and no longer releases pollen.	Added phenophase event and definition.
First fruits ripe	First fruits ripe	First fruits ripe	89	In at least 3 locations on the plant, a fruit has become ripe.	Change fruit to fruits, change name of PBB to same core, check if fruit is plural
		50% of fruits ripe	89c	For the whole plant, half (50%) of the fruits are ripe.	Changed fruit to fruits
		All fruits ripe	89e	For the whole plant, virtually all (95-100%) of the fruits are ripe. (Need correct definition for species dry fruit)	Added note, note may already be included in definitions
First color	-	First leaf colored	92a	In at least 3 locations on the plant, the green leaves have begun to change to their late season colors.	All will be dropped due to drought, insects, and other factors making determination of first color problematic
		25% of leaves colored	92b	For the whole plant, one-quarter (25%) of the leaves (including any that have fallen to the ground) have changed to their late season colors.	
Peak color	50% of leaves colored	50% of leaves colored	92c	For the whole plant, half (50%) of the leaves (including any that have fallen to the ground) have changed to their late season colors.	PBB will change wording

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		75% of leaves colored	92d	For the whole plant, three-quarters (75%) of the leaves (including any that have fallen to the ground) have changed to their late season colors.	
All leaves colored	All leaves colored	All leaves colored	92e	For the whole plant, virtually all (95-100%) of the leaves (including any that have fallen to the ground) have changed to their late season colors and there is virtually no green left in the leaves.	PBB will add phenophase event
		In at least 3 locations on the plant, a leaf easily falls off into your hand when touched or gently handled. First leaf fallen may also be indicated by the presence of at least 3 leaves on the ground below the plant (that are not apparently from another individual nearby).	93		All deleted
		25% of leaves fallen	94	For the whole plant, one-quarter (25%) of the leaves have fallen.	
	50% of leaves fallen	50% of leaves fallen	95	For the whole plant, half (50%) of the leaves have fallen.	
		75% of leaves fallen	96	For the whole plant, three-quarters (75%) of the leaves have fallen.	
	All leaves fallen	All leaves fallen	97	For the whole plant, virtually all (95-100%) of the leaves have fallen.	

Appendix A.2 Phenophase Definitions: Deciduous Tree/Shrubs Insect Pollinated

PBB	Core	Intensive	BBCH code	Definition	Notes
	Leaf budburst	Leaf budburst	9	In at least 3 locations on the plant, a leaf bud shows green tips.	Add phenophase BBCH 9, added definition
First leaves unfolded	First leaves unfolded	First leaves unfolded	11	In at least 3 locations on the plant, a young leaf has completely unfolded from the bud so that the petiole (leaf stalk) or leaf base is visible. The leaf may need to be bent backwards to see the petiole stalk or leaf base.	Change first leaf to first leaves unfolded, change leaf to leaves, BBCH changed from 10a to 11, change definition
All leaves unfolded	All leaves unfolded	All leaves unfolded	19	For the whole plant, virtually all (95-100%) of the young leaves have completely unfolded from the bud so that the leaf stalk or leaf base is visible.	New phenophase and definition, BBCH 19
		25% of full leaf size elongation	43	The majority of young leaves have unfolded completely and have expanded elongated to one-quarter (25%) of their mature size. Leaf elongation size may also be estimated by viewing the canopy as a whole. At 25% of full leaf size elongation , the canopy appears to be approximately one-quarter (25%) full.	

PBB	Core	Intensive	BBCH code	Notes
		50% of full leaf size elongation	45	The majority of young leaves have unfolded completely and have expanded elongated to half (50%) of their mature size. Leaf elongation size may also be estimated by viewing the canopy as a whole. At 50% of full leaf size elongation, the canopy appears to be approximately one-half (50%) full.
	75% of full leaf size elongation	75% of full leaf size elongation	47	The majority of young leaves have unfolded completely and have expanded elongated to three-quarters (75%) of their mature size. Leaf elongation size may also be estimated by viewing the canopy as a whole. At 75% of full leaf size elongation, the canopy appears to be approximately three-quarters (75%) full.
		Full leaf size elongation	49	The majority of young leaves have unfolded completely and have expanded elongated to 95-100% of their mature size. At full leaf size elongation, the canopy appears to have reached its full density.
First flowers	First flowers	First flowers	60	In at least 3 locations on the plant, a flower has opened completely. Flowers are considered 'opened' when the reproductive parts are visible between unfolded or opened flower parts.
				Flower changed to flowers; PBB first flowers generally defined by male flowers (just male plants for dioecious spp.); group discussed option of observer reporting Male and/or Female and/or Unknown for core and intensive; need to consider data issues with reporting such for dioecious or monoecious observations

PBB	Core	Intensive	BCH code	Notes
Full flower	Full flower	Full flower	65	For the whole plant, half (50%) of the flowers have opened. Added Full flower to Core, if 50% criteria does not work for species do not include in core and intensive phenophase events; developed new phenophase event definition.
End of flowering	End of flowering	End of flowering	69	The last visible flower has begun to wither and no longer looks fresh. PBB will adapt definition; definition changed, phenophase event name changed
First fruits ripe	First fruits ripe	First fruits ripe	89	In at least 3 locations on the plant, a fruit has become ripe. Change fruit to fruits, change name of PBB to same core, a species specific definition is needed for fruit ripening (fleshy or dry)
		50% of fruits ripe	89c	For the whole plant, half (50%) of the fruits are ripe. Changed fruit to fruits
		All fruits ripe	89e	For the whole plant, virtually all (95-100%) of the fruits are ripe.
First color	-	First leaf colored	92a	In at least 3 locations on the plant, the green leaves have begun to change to their late season colors. All will be dropped due to drought, insects, and other factors making determination of first color problematic
		25% of leaves colored	92b	For the whole plant, one-quarter (25%) of the leaves (including any that have fallen to the ground) have changed to their late season colors.

PBB	Core	Intensive	BCH code	Notes
Peak color	50% of leaves colored	50% of leaves colored	92c	For the whole plant, half (50%) of the leaves (including any that have fallen to the ground) have changed to their late season colors. PBB will change wording
		75% of leaves colored	92d	For the whole plant, three-quarters (75%) of the leaves (including any that have fallen to the ground) have changed to their late season colors.
All leaves colored	All leaves colored	All leaves colored	92e	For the whole plant, virtually all (95-100%) of the leaves (including any that have fallen to the ground) have changed to their late season colors and there is virtually no green left in the leaves. PBB will add phenophase event
		First leaves fallen	93	In at least 3 locations on the plant, a leaf easily falls off into your hand when touched or gently handled. First leaf fallen may also be indicated by the presence of at least 3 leaves on the ground below the plant (that are not apparently from another individual nearby). All deleted
		25% of leaves fallen	94	For the whole plant, one-quarter (25%) of the leaves have fallen.

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PBB	Core	Intensive	BBCH code	Notes
	50% of leaves fallen	50% of leaves fallen	95	For the whole plant, half (50%) of the leaves have fallen.
		75% of leaves fallen	96	For the whole plant, three-quarters (75%) of the leaves have fallen.
	All leaves fallen	All leaves fallen	97	For the whole plant, virtually all (95-100%) of the leaves have fallen.
		First flower buds	51	In at least 3 locations on the plant, an unopened flower bud is visible.
				Should these be added to intensive, ask Chip T. about his definition of this phenophase

Appendix A.3 Phenophase Definitions: Broadleaf Evergreen

PBB	Core	Intensive	BBCH code	Definition	Notes
	Leaf budburst break	Leaf budburst break	9 7	In at least 3 locations on the plant, a leaf bud shows green tips. the very first green of a breaking leaf bud is visible.	Add phenophase BBCH 7 (or 9?), added definition this was changed in the other trees and I think we just forgot to change it here
First leaves unfolded	First leaves unfolded	First leaves unfolded	11	In at least 3 locations on the plant, a young leaf has completely unfolded from the bud so that the petiole (leaf stalk) or leaf base is visible. The leaf may need to be bent backwards to see the petiole stalk or leaf base.	change phenophase event name to match Decid tree, change phenophase event definition to DT, change BBCH from 10a to 11; added to PBB depending on how distinctive the event and how easy to see for a given spp.
All leaves unfolded	All leaves unfolded	All leaves unfolded	19	For the whole plant, virtually all (95-100%) of the young leaves have completely unfolded from the bud so that the leaf stalk or leaf base is visible.	New phenophase and definition, BBCH 19
		25% of full leaf size elongation	43	The majority of new young leaves have unfolded completely and have expanded elongated to one-quarter (25%) of the size of older leaves on the plant.	
		50% of full leaf size elongation	45	The majority of new young leaves have unfolded completely and have expanded elongated to half (50%) of the size of older leaves on the plant.	
	75% of full leaf size elongation	75% of full leaf size elongation	47	The majority of new young leaves have unfolded completely and have expanded elongated to three-quarters (75%) of the size of older leaves on the plant.	

PBB	Core	Intensive	BBCH code	Definition	Notes
		Full leaf size elongation	49	The majority of new young leaves have unfolded completely and have expanded elongated to 95-100% of the size of older leaves on the plant.	
First flowers	First flowers	First flowers	60	In at least 3 locations on the plant, a flower has opened completely. Flowers are considered 'opened' when the reproductive parts are visible between unfolded or opened flower parts.	Change flower to flowers
Full flower	Full flower	Full flower	65	For the whole plant, half (50%) of the flowers have opened.	Added Full flower to Core, if 50% criteria does not work for species do not include in core and intensive phenophase events; developed new phenophase event definition.
End of flowering	End of flowering	End of flowering	69	The last visible flower has begun to wither and no longer looks fresh.	PBB will adapt definition; definition changed, phenophase event name changed
First fruits ripe	First fruits ripe	First fruits ripe	89	In at least 3 locations on the plant, a fruit has become ripe.	Change fruit to fruits, First fruits ripe added to PBB
		50% of fruits ripe	89c	For the whole plant, half (50%) of the fruits are ripe.	Change fruit to fruits
		All fruits ripe	89e	For the whole plant, virtually all (95-100%) of the fruits are ripe.	Change fruit to fruits
					Change first leaf fallen to first leaves fallen, changed phenophase event definition; probably the best way to handle this is to add a species-specific portion to explain coloring and amount of leaf fall to look for
	Leaves fallen	Leaves fallen	93	In several locations on the plant, leaves from previous years' growth have recently fallen or fall from the stem upon gentle handling.	

Appendix A.4 Phenophase Definitions: Conifer

PBB	Core	Intensive	BBCH code	Definition	Notes
	Budburst	Budburst	9	In at least 3 locations on the plant, a bud has broken and the newly developing stem (candle) has begun to push through the bud scales.	Consult with conifer expert for correct terminology (bud break? bud expansion?), appropriate only for some species; PA suggests to define BBCH 01 - budswell. Budswell consistently occurs just before first needles for all species. Generally conifers have significant budswell and elongation before needles are visible.
First needles	First needles	First needles	10a	In at least 3 locations on the plant, the young needles have begun to visibly emerge or unfold along the developing stem.	PBB change to First needles PBB will drop, too difficult to observe for mature tree species and does not have a well articulated value for linking to remote sensing or other aspects of phenology studies
Full leaf					

PBB	Core	Intensive	BBCH code	Definition	Notes
		50% stem elongation	35	The majority of developing stems are 50% of the length of the stems from the previous year. The length of stems from the previous year is determined by measuring the distance between nodes that mark the beginning and end of the stem growth on that branch in the previous year.	
		Full stem elongation	39	The majority of developing stems are 100% of the length of the stems from the previous year. The length of stems from the previous year is determined by measuring the distance between nodes that mark the beginning and end of the stem growth on that branch in the previous year.	
		75% of full needle size elongation	47	The majority of developing stems have elongating needles that are three-quarters (75%) as long as the length of the needles on the previous year's growth.	
		First male cones	51	In at least 3 locations on the plant, a male cone (strobilus) has emerged. A few to many individual pollen sacs (which look tiny balloons) have visibly emerged, though they may be quite small.	Change cone to cones 'remove from the bud' in phenophase event description, remove phenophase event from Core

PBB	Core	Intensive	BBCH code	Definition	Notes
First pollen	First pollen	First pollen	60	In at least 3 locations on the plant, the pollen sacs on a male cone (strobilus) have broken and pollen is released when the cone is gently shaken or blown.	Changed name to first pollen
Full pollen	Full pollen	Full pollen	65	For the whole plant, the pollen sacs on half (50%) of male cones have broken and pollen is released when the cone is gently shaken or blown.	Added phenophase event and definition.
First cones ripe	First female cones ripe	First female cones ripe	89	In at least 3 locations on the plant, a female cone has become ripe. (Species definition follows).	Changed PBB phenophase event name, added core/intensive definitions; note this stage is not recorded for serotinous species such as lodgepole pine
	Needles Leaves fallen	Needles Leaves fallen	93	In several locations on the plant, needles leaves from previous years' growth have recently fallen or fall from the stem upon gentle handling.	Change first leaf fallen to first leaves fallen, changed phenophase event definition; PBB notes this is very difficult to observe in a consistent way and does not include because of this difficulty; probably the best way to handle this is to add a species-specific portion to explain coloring and amount of needle fall to look for

Appendix A.5 Phenophase Definitions: Herbaceous Broadleaf

PBB	Core	Intensive	BBCH code	Definition	Notes
	Emergence above ground	Emergence above ground	9	New growth of the plant has begun above the soil surface, with aboveground buds showing green tips, or new shoots breaking through the soil surface.	
	First leaves unfolded	First leaves unfolded	11	At least one young leaf on the plant has completely unfolded from the emerging stem so that the petiole (leaf stalk) or leaf base is visible. The leaf may need to be bent backwards to see the petiole stalk or leaf base.	should we add something like this to herbs? I am thinking of plants that emerge really early (like my daffodils during a warm spell in January), then hang out with green tips aboveground until it warms up enough for leaf emergence in April: for annuals we'd have to specify this is the first true leaf and not cotyledons
First flowers	First flowers	First flowers	60	At least one flower on the plant has opened completely. Flowers are considered 'opened' when the reproductive parts are visible between unfolded or opened flower parts.	Change flower to flowers
End of flowering	End of flowering	End of flowering	69 67	The last visible flower has begun to wither and no longer looks fresh.	Change to End of flowering, changed definition
First fruits ripe	First fruits ripe	First fruits ripe	89	At least one fruit on the plant has become ripe.	PBB changed label, fruit to fruits
	All leaves senesced	All leaves senesced	97	Of the leaves that developed this season, virtually all (95-100%) are dried and dead. (Add species specific definitions).	

Appendix A.6 Phenophase Definitions: Grass

Core	Intensive	BBCH code	Definition	Notes
Emergence above ground	Emergence above ground	10a	New growth of the plant has begun above the soil surface with the appearance of green leaf tips that show no signs of aging.	we also might want to consider breaking this into BBCH 9 and BBCH 11 instead of using BBCH 10
First inflorescences	First inflorescences	51 55	The tip of at least one inflorescence on the plant has emerged from the sheath and is visible.	Change inflorescence to inflorescences add 50% inflorescence?
First flowers	First flowers	60	At least one flower on the plant has opened completely. Flowers are considered 'opened' when the reproductive parts are visible between unfolded or opened flower parts.	Add first flowers to Core, change flower to flowers,
End of flowering	End of flowering	69	All spikelets have completed flowering but some dehydrated anthers may remain.	Change all phenophase event names to 'End of flowering'; Core phenophase should be worded that this is advanced for some plant species: PBB notes that end of flowering is often difficult to record accurately without careful training
	First medium milk seeds	75	At least one seed on the plant has reached its full size but is still green, and exudes a milky substance when squeezed.	Change seed to seeds, check with grass expert if first seeds or 50% seeds
	First soft dough seeds	85	At least one seed on the plant appears doughy when squeezed, but does not hold a fingernail impression.	Change seed to seeds, check with grass expert if first seeds or 50% seeds

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Core	Intensive	BCH code	Definition	Notes
<div style="background-color: #cccccc; height: 100px; width: 100%;"></div>	<div style="background-color: #cccccc; height: 100px; width: 100%;"></div>	89	<p>At least one seed on the plant is hard when squeezed and is difficult to divide with a fingernail. Seeds may also be considered ripe when they are dispersed by wind or fall into your hand when the plant is handled.</p>	<p>Change all phenophase event names to 'First seeds ripe', check with grass expert if first seeds or 50% seeds</p>
		97	<p>Of the leaves that developed this season, virtually all (95-100%) are dried and dead.</p>	
First seeds ripe	First seeds ripe			
All leaves senesced	All leaves senesced			

Appendix B: Proposed changes to the method by which USA National Phenology Network observations are recorded

Some members of the Species and Protocols Working Group (SPWG) have conceived of a slightly altered framework for recording and entering phenology data that offers some significant improvements to the current system used in the NCO Core and Intensive protocols. The primary feature of the newly proposed framework is that an observer would indicate whether a plant has leaves, open flowers, and ripe fruits on each observation date. We could then allow observers to further characterize the phenological state of the leaves, flowers, and fruits.

Most importantly, the new framework would allow for the recording of multiple episodes of leafing, flowering and fruiting within a season, and would make it easier to record phenophases that may occur in an irregular or aseasonal manner through the year. The current system can capture the first instance of leaf out, flowering and fruiting for a plant in any given season, and is well-suited to plants growing in temperate regions where life stage events unfold in a predictable progression every year (see accompanying spreadsheet, “Example 1”). However, plants growing in drought-prone, subtropical, or tropical regions often experience several distinct episodes of leafing or flowering/fruiting following an unpredictable pattern of water availability (see accompanying spreadsheet, “Example 2”). The new framework can capture these second (and third, fourth, etc.) episodes. Similarly, the new framework can capture irregular phenological events that may occur in aseasonal environments, and even allows observers to record multiple leaf flushing events that might occur in temperate plants after episodes of extreme drought or insect defoliation, which may become more common with climate change.

The new system that we propose would continue to use the same phenophase event definitions that we have already developed (and recently modified in concert with Project Budburst), with only slight alterations to the wording to account for changes in grammatical tense and generality. We believe that the changes would not require any significant changes to the data model (database structure). However, they will change the way data entry choices are presented to the user on a field datasheet and online. If we adopt this new framework, the data entry form would no longer consist of a progression of phenophase events that are checked off in a chronological sequence and then not observed for the rest of the season, but the new, more flexible system would ask an observer to reassess each question (i.e., phenological state) at every visit. The new framework would obviate the need to put phenophase events in a chronological order, because each major question would be reassessed at each visit.

Summary of primary benefits of proposed changes:

1. Improves ability to capture multiple episodes of leafing, flowering, and fruiting.
 - a. Examples: Creosote and ocotillo leafing and flowering; oak second flush of leaves
2. Simplifies user interface in multiple ways:
 - a. Nested structure allows the observer to explore the general state of the plant, then to add details as appropriate in more intuitive way.
 - b. Improves web interface usability.
 - c. Could shorten the list of phenophases that we are asking the observer to observe.

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3. Maintains the observation history for each phenophase (i.e. the dates on which each phenophase was or was not assessed), which is critical for quantifying uncertainty in the data in future analyses

Items left to consider before distribution beyond the SPWG:

1. *Finish modifying definitions for Full flowering, Fruit ripe*
2. *Consider whether separate observation of male and female flowers can be incorporated*
3. *Modify definitions for the other plant functional groups (i.e. broadleaf evergreens, conifers, herbs, grasses)*
4. *Scrutinize the data model to assess what changes might be needed and consider whether this new framework will generate significantly more records to store*

Appendix C Examples associated with Appendix B

Example 1

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	W	X	Y	Z	AA	AB	AC	AD	AE	AF	A
1																																	
2	OBSERVER NAME: SPwG LOCATION: Scone Central PLANT NAME: "I Need Coffee" tree NPN Protocol: Core - deciduous tree/shrub																																
3	Key: Y = yes N = no --- = did not check																																
4	note: do not use "x" for this observation -- it's easy for observer to confuse "x" and a sloppy "y". Observer forgot to check all leaf phenophases																																
5	Do you see...																																
6																																	
7				1-Apr	4-Apr	7-Apr	10-Apr	13-Apr	18-Apr	19-Apr	22-Apr	25-Apr	30-Apr	2-May	4-May	7-May																	
8	Leaf budburst?	N	Y	Y	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
9	Unfolded leaves?	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
10	All leaves unfolded?	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
11	= 75% leaf elongation?	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
12	= 50% leaves colored?	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
13	All leaves colored?	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
14	= 50% leaves fallen?	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
15	Open flowers?	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
16	Full flowering?	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
17	Ripe fruit?	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N	N
18																																	
19																																	
20																																	
21																																	
22																																	
23																																	
24	Phenophase events for the "I Need Coffee" tree Flowering dates: First flower date: April 18 with error of -5days End flower date: April 25 with error of -3days																																
25	Leaves	Leaf budburst	In at least 3 locations on the plant, a leaf bud shows green tips.																														
26		Leaves unfolded	In at least 3 locations on the plant, an unfolded leaf is visible. A leaf is considered "unfolded" when the leaf base or leaf petiole (stalk) is visible. For young leaves that have recently emerged from the bud, the leaf tip may need to be uncurled to see whether																														
27		All leaves unfolded	For the whole plant, virtually all (95-100%) of the leaves are unfolded.																														
28		= 75% leaf size **	The majority of leaves have unfolded and have elongated to three-quarters (75%) of their mature size. This may also be estimated by viewing the canopy as whole: at 75% leaf elongation, the canopy appears to be approximately three-quarters (75%) full.																														
29		= 50% leaves colored	For the whole plant, half (50%) of the leaves (including any that have fallen to the ground) have changed to their late-season colors.																														
30		All leaves colored	For the whole plant, virtually all (95-100%) of the leaves (including any that have fallen to the ground) have changed to their late-season colors, and there is virtually no green remaining in the leaves.																														
31		= 50% leaves fallen	For the whole plant, half (50%) of the leaves have fallen.																														
32	Flowers	Open flowers	In at least 3 locations on the plant, an open fresh flower is visible. Flowers are considered "open" when the reproductive parts are visible between unfolded or open flower parts. Do not include spent (wilted) flowers that remain on the plant.																														
33		Full flowering	For the whole plant, half (50%) of the flowers are open and fresh.																														
34	Fruits	Fruits ripe	In at least 3 locations on the plant, a fruit has become ripe. <i>(insert species-specific definition here)</i> .																														
35																																	
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Example 2

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V
1																						
2		OBSERVER NAME: SPWG																				
3		LOCATION: Scone Central							Key: Y = yes N = no --- = did not check			note: do not use "x" for this observation -- it's easy for observer to confuse "x" and a sloppy "y".										
4		PLANT NAME: Hypothetical #1 (an indecisive plant)																				
5		NPN Protocol: Core - deciduous tree/shrub																				
6		Observer forgot to check all leaf phenophases																				
7		Do you see...																				
8							1-Apr	4-Apr	7-Apr	10-Apr	13-Apr	18-Apr	19-Apr	22-Apr	25-Apr	30-Apr	2-May	4-May	7-May			
9		Leaf budburst?		N	Y	Y	N	Y	Y	Y	Y	N	N	N	---	N	N	N	N			
10		Unfolded leaves?		N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	---	Y	Y	Y	Y	N		
11		All leaves unfolded?				N	N	N	N	N	N	Y	Y	Y	---	Y	Y	Y	Y			
12		≥75% leaf elongation?				N	N	N	N	N	N	Y	Y	Y	---	Y	Y	Y	Y			
13		≥50% leaves colored?				N	N	N	N	N	N	N	N	N	---	N	Y	Y	Y			
14		All leaves colored?													---	N	N	Y	Y			
15		≥50% leaves fallen?					N	N	N	N	N	N	N	N	---	N	N	Y	Y			
16		Open flowers?		N	N	N	N	N	Y	N	N	N	N	Y	Y	Y	Y	N	N			
17		Full flowering?							N	N	N	N	N	Y	N	N	N	N				
18		Ripe fruit?		N	N	N	N	N	N	N	N	Y	Y	Y	---	Y	Y	Y	N			
19																						
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Two distinct leaf budburst episodes

Two distinct flowering episodes

First flowering pulse:
 First flower date: April 13 with error of -3days
 End of flowering date: April 18 with error of -5days

Second flowering pulse:
 First flower date: April 25 with error of -3days
 End of flowering date: May 4 with error of -2days

Even though observer missed one date for fruit observation, still possible to extract total fruiting duration.

Appendix D: NPN, NCO, and PPP descriptions

USA-National Phenology Network - Plant Phenology Program (PPP)

PPP Coordinator FY 2009 Statement of Work

The USA National Phenology Network

The USA National Phenology Network (NPN) is a relatively new partnership among NGOs, academia, citizen volunteers, federal agencies, and other organizations. The goal and mission of the NPN is to establish a nationwide network of phenological observations of plants and animals to understand better how natural ecological systems respond to changing environments through changes in phenology, and to aid the development and implementation of facilities and tools required for human adaptation to future climate conditions. This effort employs the observational skills of scientists, managers, the public and other stakeholders to document dynamic aspects of plant and animal biology that are affected by seasonal changes, such as foliage emergence, fruit production, migration, and reproduction.

The National Coordinating Office (NCO) for the NPN, located in Tucson, Arizona, guides the development of the NPN and facilitates communication among the various partners of the NPN. The NCO was established in August 2007 by a cooperative agreement between USGS and the University of Arizona (UA). USGS provides base-stable support for NCO operations, including support for the Executive Director. UA provides 0.5 FTE for an Assistant Director, as well as office space, limited office supplies, and some administrative assistance. Core programs in the NCO include plant and animal phenology programs, remote sensing for phenology, education and outreach, network development, and development of program-critical cyberinfrastructure.

Plant Phenology Program 2009

The NPN Plant Phenology Program (PPP) coordinates and facilitates plant phenology monitoring activities as related to the four tiers of information extent and scale within the NPN: intensive science sites, extensive science sites, volunteer and education networks, and remote sensing applications. The program works with other NCO staff to build partnerships and to develop widespread interest in monitoring of plant phenology. It oversees NCO standards for plant phenology monitoring and promotes consistency of standards among collaborators participating within each of the four tiers. The PPP works with the Cyber-infrastructure Group of the NCO to document and assure plant phenology data integrity from collection, import, maintenance, and client download. The PPP coordinates with the Wildlife Phenology Program to develop parallel and interfaced phenology monitoring. Finally, the program promotes the application of plant phenology data toward educational, applied, and scientific projects.

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Four overarching goals have been established for the PPP in 2009. The PPP coordinator for 2009 is U.S. Geological Survey ecologist Kathryn Thomas. While the position is best served with a full time coordinator, Thomas can only commit to half time (0.5 FTE) in 2009 because of other project commitments. Goals, objectives and outcomes for FY 2009 are as follows:

Goal one: *Develop vetted plant phenology monitoring protocols consisting of a comprehensive listing of plant species, their defined phenophase events, and observation procedures for a national phenology monitoring program focused on plants as sensitive indicators of environmental variation and climate change*

Goal two: *Coordinate within the NCO to promote and develop an integrated and responsive coordinating structure.*

Goal three: *Develop interactions of PPP with NPN partners to promote and develop widespread participation in plant phenology monitoring, efficient observation reporting, and effective data management*

Goal four: *Develop and implement PPP communication plan and participate in wider NPN communication plan*

Goal five: *Promote long-term development of PPP operations and reporting*