



PRESERVICE TEACHERS' DECISION-MAKING ON INVASIVE SPECIES MANAGEMENT: A KNOWLEDGE-ACTION DISCONNECT ACROSS CONTEXTS

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Abstract: Decisions about invasive species management often require individuals to balance ecological knowledge with ethical considerations and practical constraints, particularly in everyday and educational contexts. Grounded in frameworks of ecological literacy and socioscientific issues, this study conceptualizes invasive species management as a context-dependent decision-making process that integrates scientific knowledge, ethical reasoning, and professional judgment. Using scenario-based inquiry, 191 Korean preservice biology teachers responded to two contrasting situations involving red-eared slider turtles (*Trachemys scripta elegans*): managing an abandoned pet in a household context and addressing overpopulation within a school breeding program. Qualitative content analysis revealed notable discrepancies between preservice teachers' understanding of invasive species and ecosystem-disrupting species, as well as inconsistencies between articulated ecological concerns and recommended actions. Decision-making patterns differed markedly by context, with household scenarios shaped primarily by emotional and practical considerations, whereas institutional scenarios emphasized professional responsibility and institutional management. These findings highlight persistent gaps in preservice teachers' understanding of invasive species management and demonstrate the powerful influence of context on professional judgment. The study highlights important implications for science teacher education, particularly the need to foster integrated decision-making competencies that connect ecological understanding, ethical reasoning, and context-sensitive decision-making for managing invasive species.

Keywords: Invasive species, ecosystem disruption, preservice teachers, decision-making, scenario-based learning, science education, biology teacher education

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Introduction

The intentional or unintentional introduction of invasive species is widely recognized as one of the most significant ecological challenges facing contemporary ecosystems worldwide. In the Republic of Korea, species such as the red-eared slider turtle (*Trachemys scripta elegans*), bullfrogs (*Lithobates catesbeianus*), and nutria (*Myocastor coypus*) have established self-sustaining populations that substantially disrupt native biodiversity and ecosystem functioning (NIE, 2021a, 2021b). The impacts of invasive species, however, extend beyond ecological systems into educational, ethical, and social domains, particularly when these organisms are used in school curricula or kept as companion animals.

The red-eared slider turtle (*Trachemys scripta elegans*), native to North America, is widely traded as a companion animal and serves as a representative example of the challenges associated with invasive species management. As these animals mature, their care becomes increasingly demanding due to factors such as greater space requirements, specialized diets, and behavioral changes. These practical difficulties often exceed the capacity of individual caretakers and institutions, increasing the likelihood of abandonment or improper management.

In Korea, red-eared slider turtles were introduced primarily through the pet trade and their use in educational settings. As the animals grow and become more difficult to manage, many are intentionally or unintentionally released into local waterways. Within Korean freshwater ecosystems, this species exhibits high adaptability and reproductive capacity, competes with native freshwater turtles for food and habitat, and has been reported to contribute to ecological disruption in ponds and streams. When long-term care becomes unmanageable, individuals may abandon turtles in natural environments, while schools that incorporate these animals into educational programs often face rapid population growth due to successful reproduction. These situations generate institutional dilemmas related to population con-



trol, ecological responsibility, and ethical decision-making. Notably, the red-eared slider turtle has been identified by the International Union for Conservation of Nature (IUCN) as one of the world's 100 most invasive species, with documented negative impacts on native turtle populations in Korea.

Education has been identified as a pivotal factor in altering human behavior concerning environmental management (Amézquita-Galindo et al., 2025). Environmental education aims to cultivate an appreciation for nature and the impact of humans on it, while introducing citizens to scientific thinking (Sosa et al., 2021). Teachers who act as environmental educators are expected to serve as mediators between scientists and students. Teachers' personal and professional perceptions of the environment and invasive species have been shown to influence how they approach their mediating role in student learning (Sosa et al., 2021). However, studies on the environmental literacy of preservice teachers reveal concerning gaps. Saribas et al. (2015) identified significant relationships between preservice teachers' scientific and environmental literacy, while also noting persistent limitations in teachers' conceptual understanding of complex environmental issues. Similarly, Rofi'ah et al. (2022) demonstrated that environmental literacy among biology teacher candidates varies significantly across different dimensions, with behavioral aspects showing particular deficits.

Recent research on invasive species education underscores the significance of teacher preparation. Sosa et al. (2021) found that 56% of educators were aware of biological invasions. However, a significant discrepancy was observed in the recognition of native and invasive alien species, as well as awareness of biological invasions, between natural and non-natural science teachers. Remmele and Lindemann-Matthies (2020) conducted a study to ascertain teacher students' perception of invasive alien animal species. The study revealed significant deficiencies in the teacher students' identification abilities and attitudes towards management strategies. As emphasized by Verbrugge et al. (2021), enhancing public awareness is considered a prerequisite for the effective management of invasive alien species. In this regard, environmental education is identified as a pivotal component in this process. However, their analysis of invasive alien species education projects revealed that many educational interventions lack systematic evaluation of their effectiveness in changing knowledge, attitudes, and behaviors.

A substantial body of research has documented the ecological impacts of invasive species and pedagogical approaches to environmental education. However, relatively little research has examined how preservice teachers make decisions when confronted with invasive species management dilemmas in contexts where ecological knowledge, ethical considerations, and practical constraints intersect. Furthermore, few studies have explored how contextual variations (household versus institutional settings) shape teachers' decision-making frameworks, particularly with respect to the justifications offered for proposed actions. Understanding these decision-making processes is crucial, as science teachers hold influential roles in community environmental discourse, and their informal recommendations—such as guidance provided to students on pet management—can have substantial cumulative environmental effects.

Theoretical Framework

Ecological Literacy and Environmental Education

Ecological literacy, a fundamental objective in science education, is a comprehensive understanding of ecological principles, human-environment interactions, and the capacity to take informed action (Jeronen et al., 2017). However, recent scholarship emphasizes that ecological knowledge alone is inadequate for addressing environmental challenges. Decision-making regarding invasive species requires the integration of multiple epistemic dimensions, including scientific understanding, ethical reasoning, recognition of institutional constraints, and recognition of contextual variations in professional responsibility.

A review of studies on the environmental literacy of preservice teachers reveals significant gaps in their knowledge and understanding of environmental issues. Saribas et al. (2015) discovered significant relationships between preservice teachers' scientific and environmental literacy. However, it was also noted that many teachers lack sufficient conceptual understanding to address complex environmental issues (Saribas et al., 2015). Similarly, Rofi'ah et al. (2022) demonstrated that environmental literacy among biology teacher candidates varies significantly across different dimensions, with behavioral aspects showing particular deficits.



Conceptual Framework: Invasive Species and Ecosystem Disruption

The distinction between invasive and ecosystem-disrupting species warrants particular attention in teacher education. Invasive species are defined as non-native organisms introduced by humans and have established and spread in their introduced range (Richardson et al., 2000; Pyšek & Richardson, 2012). On the other hand, ecosystem-disrupting species substantially alter the structure, function, or composition of ecosystems (Pyšek & Richardson, 2012). The conceptual framework developed by Richardson et al. (2000) differentiates between the following:

- **Casual species:** Alien species that do not form self-replacing populations
- **Naturalized species:** Alien species that sustain self-replacing populations for at least 10 years without direct human intervention
- **Invasive species:** Naturalized alien species that produce reproductive offspring in areas distant from sites of introduction
- **Transformer species:** About 10% of invasive species that change the character, condition, form, or nature of ecosystems over substantial areas

This conceptual distinction necessitates a nuanced understanding transcending mere categorization, progressing towards functional ecological analysis – a competency deemed indispensable for biology teachers in guiding student comprehension. Recent research on invasive species education highlights the importance of teacher preparation. Sosa et al. (2021) found that 56% of educators were aware of biological invasions. However, a significant discrepancy was observed in the recognition of native and invasive alien species, as well as awareness of biological invasions, between natural and non-natural science teachers. Remmele and Lindemann-Matthies (2020) conducted a study to ascertain teacher students' perception of invasive alien animal species. The study revealed significant deficiencies in the teacher students' identification abilities and attitudes towards management strategies.

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Socioscientific Issues and Moral Reasoning in Environmental Decision-Making

The application of moral reasoning in environmental contexts has been demonstrated to engender complexity in decision-making processes, particularly in the context of the relative value assigned to individual organisms and ecological communities. The socioscientific issues (SSI) framework, developed by Sadler (2004) and advanced by Zeidler and colleagues, provides a valuable lens for understanding how teachers navigate these complex decisions. SSI are controversial, complex, and often ill-structured problems that involve a conceptual understanding of science and technology, as well as an appreciation of the social, ethical, and moral implications of scientific knowledge and technological advancements (Zeidler & Keefer, 2003; Sadler, 2011).

Teachers engaged in invasive species management face a dilemma characterized by a tension between the principles of life preservation (i.e., the welfare of individual organisms) and ecological integrity (i.e., the health of species and communities), and practical constraints (i.e., resource limitations and time commitments). Zeidler's (2025) framework for moral reasoning in science education emphasizes that scientific decisions necessitate technical competence and moral aptitude. This neo-Aristotelian model of phronetic (practical wisdom) decision-making acknowledges the role of emotive factors, including empathy, compassion, and righteous indignation, in deriving moral decisions concerning environmental issues. These tensions are further compounded in the context of educational decisions, where the objectives of pedagogy, students' emotional development, and the institution's capabilities intersect.

Teacher Decision-Making in Environmental Education

Research on teacher decision-making in environmental education reveals significant complexity. Winther and Volk's (2002) seminal study revealed that many factors, including curricular constraints, student needs, and institutional pressures, significantly influenced teachers' decision-making during the initial year of implementing



environmental education curricula. However, a paucity of research addresses how preservice teachers reach decisions when confronted with dilemmas concerning invasive species management in contexts where ecological knowledge, ethical concerns, and practical constraints collide.

Present Study

The present study examined how preservice biology teachers make decisions regarding the management of invasive species when confronted with realistic dilemmas that required the integration of ecological knowledge, ethical reasoning, and practical problem-solving. Using a scenario-based inquiry approach, this study examined the relationship between teachers' conceptual understanding of invasive species and their practical recommendations for decision-making, specifically incorporating the red-eared slider turtle in household and institutional contexts. The following research questions were addressed:

RQ 1. To what extent do preservice teachers demonstrate conceptual alignment between invasive and ecosystem-disrupting species?

RQ 2. When managing invasive species, how do preservice teachers' decision-making processes and reasoning patterns differ between household and institutional contexts?

RQ 3. What patterns emerge in preservice teachers' reasoning as they navigate tensions between ecological concerns, life ethics, emotional considerations, and institutional constraints?

Research Methodology

Study Design and Analytical Framework

This study adopted a qualitative research approach, employing qualitative content analysis as the primary analytical framework. While selected quantitative techniques (e.g., frequency counts and descriptive statistics) were used to summarize patterns in responses, they served a supplementary role, supporting the interpretation of qualitatively derived themes rather than constituting a primary quantitative research design. The study, grounded in ecological literacy and socioscientific issues perspectives, examined preservice teachers' decision-making across household and institutional contexts and was conducted during the 2025 academic year in South Korea.

Participants and Setting

The present study involved 191 preservice biology teachers enrolled in teacher education programs at four colleges across South Korea, representing diverse institutions nationwide rather than being concentrated in one province. The participants comprised first-year students ($n = 67$), second-year students ($n = 47$), third-year students ($n = 59$), and fourth-year students ($n = 18$), as indicated by their self-reported academic year. The sample comprised 124 females (64.9%) and 67 males (35.1%). Most participants reported prior experience in animal care, encompassing experience with pets, livestock, or educational animals. Furthermore, 26.2% of the participants were current pet owners.

Data collection took place during the biology education methodology courses and environmental science seminars, which were regular components of the coursework for the 2025 academic year. Participation was voluntary, with informed consent obtained from all participants. The research protocol was reviewed and approved by the Institutional Review Board of the host university.

Participants were recruited using a convenience sampling approach from preservice teachers majoring in biology education at the participating institutions. All eligible students who agreed to participate during the data collection period were included in the study, resulting in a final sample of 191 participants. Given the qualitative and exploratory nature of the study, the sample size was not determined through a priori statistical power calculation. Instead, the sample size reflects the total number of accessible participants within the selected institutional contexts. This sample size was deemed sufficient to capture diverse perspectives across academic years and institutions, thereby supporting the identification of meaningful patterns and themes that enhance the credibility of the findings.

Table 1
Participant Characteristics

Characteristic	Category	N	%
Gender	Female	124	64.9
	Male	67	35.1
Academic Year	1st year	67	35.1
	2nd year	47	24.6
	3rd year	59	30.9
	4th year	18	9.4
Prior Animal Care Experience	Yes	139	72.8
	No	52	27.2
Current Pet Ownership	Yes	50	26.2
	No	141	73.8

Note. N = 191.

Data Collection: Scenario-Based Inquiry

Drawing from the socioscientific issues framework (Sadler, 2011; Presley et al., 2013), two scenario-based prompts were developed to elicit preservice teachers' decision-making processes regarding invasive species management. The scenarios were designed to be authentic, contextually relevant, and ethically complex, incorporating elements that would activate multiple reasoning frameworks. The full descriptions of the scenarios are provided below.

Scenario 1 (Household Context): One day, Student A from your class approaches you with a problem. Student A has been raising a red-eared slider turtle at home, but as time has passed, the turtle has grown larger and produces increasingly foul odors, making continued care at home difficult. Student A's parents propose releasing the turtle into a nearby stream because they believe continued home care is impossible. However, Student A has become emotionally attached to the turtle and is reluctant to part with it.

Accompanying questions:

- What advice would you give to Student A in this situation?
- What is your reasoning for this advice?

Scenario 2 (Institutional Context): You have been assigned to a new school that introduced red-eared slider turtles for educational purposes three years ago. Initially, there were four turtles, but due to reproduction, the population has now grown to 50 individuals. With educational activities concluded and the turtle population becoming unmanageably large, continued care at the school is no longer possible. As the biology teacher, the school administration has asked you to handle this situation.

Accompanying questions:

- What would you do with the 50 red-eared slider turtles in this situation?
- What is your reasoning for this approach?

Following these scenarios, participants were asked to provide examples of:

- Invasive alien species
- Ecosystem-disrupting species

The red-eared slider turtle (*Trachemys scripta elegans*) was selected as the focal species for the following reasons: it represents a well-documented invasive species in Korean contexts, is commonly used in educational programs, and frequently becomes problematic as an abandoned pet. This species has been identified as one of the 100 most significant invasive species worldwide by the International Union for Conservation of Nature (IUCN), and there is documented evidence of its detrimental impact on native turtle populations in Korea.

Data Analysis Procedures

Data analysis employed systematic qualitative content analysis following established protocols (Krippendorff, 2013). Two independent coders analyzed all written responses using inductive category development to identify emergent themes in participants' decision-making recommendations for household and institutional contexts. The primary focus of the analysis was on identifying and interpreting qualitatively distinct reasoning patterns, with numerical summaries used only to illustrate the relative prevalence of emergent categories.

Participants' justifications were separately coded to identify underlying reasoning frameworks, including ecological, ethical, emotional, and practical considerations that informed their recommendations. To assess participants' understanding of invasive species and ecosystem-disrupting species concepts, researchers identified all species examples provided for each category, standardized species names to account for variations in spelling and common versus scientific names, and classified participants based on the degree of overlap between their invasive species and ecosystem-disrupting species examples. Responses with missing or incomplete species examples were excluded from this specific analysis, resulting in a final sample of $N = 189$ for the conceptual alignment classification. Inter-rater reliability was established by having two coders independently analyze 40 randomly selected responses (21.2% of the sample) for each scenario and question. Cohen's kappa coefficients were calculated for each coding scheme, yielding values ranging from .81 to .89 (all exceeding the .75 threshold for acceptable agreement). Disagreements were resolved through discussion and refinement of coding criteria.

Data Display and Synthesis

Qualitative findings were first synthesized through thematic interpretation of coded response categories. To support this interpretation, frequency distributions and percentages were calculated to summarize the relative prominence of identified themes across contexts. Comparative tables were then used as a data display tool to illustrate similarities and differences between household and institutional scenarios. Representative participant quotes were selected to exemplify each reasoning theme and to illustrate how these themes were expressed in participants' own words. Quantitative indicators served an exclusively supportive role, aiding the interpretation of qualitative patterns rather than testing hypotheses or producing statistical generalizations. Finally, exploratory chi-square analyses were conducted to examine potential associations between participant characteristics and response patterns, with results interpreted cautiously and in relation to the qualitative findings.

Research Results*Invasive Species and Ecosystem-Disrupting Species Conceptual Alignment*

Analysis of preservice teachers' species examples showed differences in how participants categorized "invasive species" and "ecosystem-disrupting species." Among the 189 participants, only 56 (29.6%) demonstrated complete conceptual alignment, providing identical species examples for both categories. A substantial plurality (69 participants, 36.5%) provided overlapping but non-identical examples across the two categories. In contrast, 64 participants (33.9%) listed entirely different species for each category.

Table 2*Conceptual Alignment Between Invasive Species and Ecosystem-Disrupting Species*

Alignment Category	<i>N</i>	%	Description
Complete Alignment	56	29.6	All species examples overlap between both categories
Partial Alignment	69	36.5	Some species overlap, some appear in only one category
No Alignment	64	33.9	Entirely different species are listed for each category

Note. $N = 189$. Two participants did not provide usable responses to both the invasive species and ecosystem-disrupting species items and were excluded from this analysis.

The most frequently mentioned species across both categories were bullfrogs (*Lithobates catesbeianus*), mentioned by 84 participants [44.4%] as invasive and 82 participants [43.4%] as ecosystem-disrupting) and nutria

(*Myocastor coypus*, mentioned by 87 participants [46.0%] as invasive and 69 participants [36.5%] as ecosystem-disrupting). Differences were observed in the frequency with which other species were listed across the two categories.

Thirteen participants (6.9%) listed no examples for invasive species, and 19 participants (10.1%) listed no examples for ecosystem-disrupting species.

Plant species were infrequently mentioned. Pink muhly grass (*Muhlenbergia capillaris*) was identified in the invasive species lists of eight participants (4.2%), although it was seldom included in categories related to ecosystem disruption. Conversely, some participants listed native species experiencing population increases within the ecosystem-disrupting category.

Table 3

Top 10 Most Frequently Mentioned Species by Category

Rank	Invasive Species	N	%	Ecosystem-Disrupting Species	N	%	Gap
1	Nutria	87	46.0	Bullfrogs	82	43.4	-
2	Bullfrogs	84	44.4	Nutria	69	36.5	-9.5
3	Bass species	43	22.8	Bass species	35	18.5	-4.3
4	Red-eared slider turtle	35	18.5	Red-eared slider turtle	32	16.9	-1.6
5	Bluegill	19	10.1	Bluegill	14	7.4	-2.7
6	Large-mouth bass	13	6.9	Large-mouth bass	9	4.8	-2.1
7	None/Unable to answer	13	6.9	None/Unable to answer	19	10.1	+3.2
8	Flower insects	11	5.8	-	-	-	-
9	Pink muhly grass	8	4.2	-	-	-	-

Decision-Making and Reasoning in Situation 1 (Household Context)

Advice Regarding Household Pet Abandonment

When confronted with the household scenario, preservice teachers recommended various courses of action, with multiple recommendations often reported by individual participants. The most frequently recommended strategy (109 participants, 57.7%) involved directing Student A's family to release the turtle into a nearby stream or natural waterway. In their written responses, 77 participants (40.7%) explicitly articulated concerns about invasive species and ecosystem disruption in their reasoning.

The second most prevalent recommendation (70 participants, 37.0%) emphasized responsibility and commitment, suggesting that Student A should continue to care for the turtle or carefully consider the emotional and ethical consequences of abandonment. Additional management strategies were also reported. In the survey, 63 participants (33.3%) suggested rehoming the animals by identifying alternative caretakers, while 39 (20.6%) proposed educational interventions.

Table 4

Decision-Making Recommendations for Situation 1: Household Context

Decision Category	N	%	Description
Release to natural waterways	109	57.7	Recommend releasing the turtle into the stream or the natural habitat
Emphasize responsibility/continued care	70	37.0	Encourage the student/family to continue caring for the turtle
Rehoming/find alternative caretakers	63	33.3	Find other individuals/families to adopt a turtle
Educational intervention	39	20.6	Teach students about invasive species and ecological impacts
Problem-solving approaches	31	16.4	Address odor/care issues through improved management
Institutional placement	24	12.7	Direct family to animal care centers or organizations

Note. Categories are not mutually exclusive; participants often suggested multiple approaches.



Reasoning for Household Context Recommendations

A subsequent analysis of the participants' reasoning for their recommendations in Situation 1 identified multiple categories of reasoning, including ecological, ethical, emotional, and practical considerations. The most prevalent rationale (77 participants, 40.7%) pertained to ecological concern regarding the impacts of invasive species. Emotional considerations (52 participants, 27.5%) and ethical responsibility (33 participants, 17.5%) were also frequently articulated, along with references to life ethics (14 participants, 7.4%). At the same time, release was recommended by 109 participants (57.7%) in the household context.

Table 5
Reasoning Themes for Situation 1 Decisions

Reasoning Theme	N	%	Representative Quote
Ecological concern	77	40.7	"Red-eared slider turtles are invasive species, so releasing them into streams could disrupt existing ecosystems."
Emotional considerations	52	27.5	"The student has developed a strong emotional attachment to the turtle. We should acknowledge the student's feelings."
Ethical responsibility	33	17.5	"Once you choose to raise a pet, you become responsible for that animal's welfare throughout its life."
Life ethics	14	7.4	"Killing animals is ethically problematic. We must find solutions that preserve life."

Note. Categories are not mutually exclusive; participants often employed multiple reasoning frameworks.

*Decision-Making and Reasoning in Situation 2 (Institutional Context)**Management Solutions for School Population*

In addressing the institutional scenario, preservice teachers' recommendations differed from those reported in the household context. The most frequently recommended solution (81 participants, 42.9%) involved institutional placement, specifically advising the school to contact animal welfare organizations, zoos, aquariums, or specialized reptile rescue facilities.

A mere 17 participants (9.0%) advocated for the release of the turtles into natural water bodies, compared with 109 participants (57.7%) who recommended release in the household context.

Table 6
Decision-Making Recommendations for Situation 2: School Context

Decision Category	N	%	Description
Institutional placement	81	42.9	Contact zoos, aquariums, and animal welfare organizations
Rehoming/redistribution	60	31.7	Find alternative homes through community outreach
Consultation with authorities	57	30.2	Seek guidance from environmental authorities/experts
Educational use (partial retention)	37	19.6	Retain some turtles for education, dispose of the remainder
Release to nature	17	9.0	Release turtles into natural waterways
Euthanasia/culling	8	4.2	Humanely euthanize the population
Population control measures	5	2.6	Separate males/females to prevent reproduction

Note. Categories are not mutually exclusive; participants often suggested multiple approaches.

Reasoning for Institutional Context Recommendations

The reasoning patterns exhibited in Situation 2 differed from those reported in Situation 1. Life ethics achieved greater prominence in the institutional context (33 participants, 17.5%) compared to Situation 1 (7.4%), where life ethics was referenced less frequently.

Ecological concern remained the most frequently articulated reasoning theme (75 participants, 39.7%), alongside references to alternative-seeking strategies, institutional constraints, and effectiveness or safety considerations.

Table 7
Reasoning Themes for Situation 2 Decisions

Reasoning Theme	N	%	Representative Quote
Ecological concern	75	39.7	"We cannot release 50 invasive turtles into local waterways. This would cause substantial ecosystem disruption."
Alternative-seeking	35	18.5	"We should systematically contact other schools, zoos, and reptile rescue organizations."
Life ethics	33	17.5	"Euthanasia would be unethical given that viable alternatives exist. These are living beings."
Constraint recognition	22	11.6	"Schools have limited resources for indefinite animal care, and 50 turtles represent significant costs."
Effectiveness/safety	11	5.8	"The most responsible approach would ensure ecological safety and animal welfare."

Note. Categories are not mutually exclusive; participants often employed multiple reasoning frameworks.

*Comparative Analysis: Context-Dependent Differences in Decision-Making**Comparative Analysis: Decision-Making Patterns Across Contexts*

A comparative analysis examined differences in decision-making patterns between household and institutional contexts.

Statistical analysis revealed an association between context and decision-making patterns ($\chi^2 = 64.23$, $p < .001$). The strength of the association was quantified using Cramer's V ($V = .58$).

Table 8
Comparative Decision-Making Patterns: Household vs. Institutional Contexts

Decision Category	Situation 1 Household N (%)	Situation 2 School N (%)	Difference	Change (%)
Release to nature	109 (57.7)	17 (9.0)	-92	-85
Institutional placement	24 (12.7)	81 (42.9)	+57	+237
Consultation with authorities	~0 (0)	57 (30.2)	+57	+∞
Rehoming/redistribution	63 (33.3)	60 (31.7)	-3	-5
Educational use	N/A	37 (19.6)	+37	N/A
Euthanasia	~0 (0)	8 (4.2)	+8	N/A

Reasoning Framework Activation

The reasoning patterns differed across contexts. Emotional considerations, prominent in 27.5% of Situation 1 responses, were reported less frequently in Situation 2, appearing in fewer than 5% of responses. Conversely, constraint recognition was reported as a distinct reasoning theme in Situation 2 (11.6%), but appeared less frequently in Situation 1.

Table 9*Comparative Reasoning Patterns: Household vs. Institutional Contexts*

Reasoning Theme	Situation 1 Household N (%)	Situation 2 School N (%)	Difference	Change (%)
Ecological concern	77 (40.7)	75 (39.7)	-2	-1
Life ethics	14 (7.4)	33 (17.5)	+19	+136
Emotional considerations	52 (27.5)	<10 (~5)	-42	-81
Ethical responsibility	33 (17.5)	N/A	N/A	N/A
Constraint recognition	<10 (~5)	22 (11.6)	+12+	+140+
Alternative-seeking	<10 (~5)	35 (18.5)	+25+	+270+

The Release Paradox: Knowledge-Action Disconnection

Table 10 presents the distribution of participants who articulated ecological concerns, those who recommended release, and those who reported both response patterns in the household context. In Situation 1, 77 participants articulated ecological concerns, 109 recommended releases, and approximately 45 participants exhibited both ecological concerns and release recommendations. These distributions summarize the co-occurrence of reasoning categories and decision recommendations within the household scenario.

Table 10*The Release Paradox in Situation 1: Ecological Knowledge vs. Decision-Making*

Measure	N	%	Implication
Participants who articulated ecological concerns	77	40.7	Demonstrate knowledge of invasive species risks
Participants who recommended the release	109	57.7	Recommend ecologically problematic action
Overlap: Ecological concern + Release recommendation	~45	~23.8	Knowledge-action disconnection

Discussion*The Conceptual Gap: Understanding Invasive Species and Ecosystem Disruption*

The findings of this study suggest a substantial conceptual gap in preservice teachers' understanding of the relationship between invasive species and ecosystem disruption. Although these concepts are closely related in ecological theory, many participants did not consistently align them in their reasoning. This lack of conceptual clarity has important implications for science education, as it suggests that even future biology teachers may struggle to apply foundational ecological distinctions in practice. Similar difficulties have been reported in previous research on invasive species education, which highlights the conceptual complexity and contextual nature of invasion biology (Remmele & Lindemann-Matthies, 2020; Sosa et al., 2021).

Ecological frameworks clearly distinguish between invasive species, defined as non-native organisms that establish and spread beyond their sites of introduction, and ecosystem-disrupting species, which significantly alter the structure or function of ecosystems (Richardson et al., 2000). Importantly, not all invasive species cause substantial ecological disruption, and some disruptive ecological dynamics may involve native or naturalized species. Understanding these distinctions requires more than categorical knowledge; it demands functional ecological reasoning that considers mechanisms such as competition, predation, and cumulative population effects.

The frequent identification of well-known invasive species with documented ecological impacts suggests that preservice teachers possess general awareness of prominent cases emphasized in environmental discourse. However, inconsistencies in the classification of other species indicate uncertainty about how ecological impact

should be evaluated. This pattern suggests that non-native status may be more readily recognized than the ecological processes through which species influence ecosystems. From a pedagogical perspective, such conceptual ambiguity risks oversimplified learning and may limit students' ability to engage in nuanced ecological reasoning.

This conceptual ambiguity is further illustrated in participants' own explanations. For example, one preservice teacher identified red-eared slider turtles as invasive but nevertheless described them primarily in terms of their origin rather than ecological function, stating that "they are invasive because they came from another country." Such responses suggest that non-native status alone was often treated as sufficient justification, with little reference to mechanisms of ecological impact such as competition or population growth. In contrast, a smaller number of participants demonstrated more functionally grounded reasoning by explicitly linking disruption to ecological processes, noting that "when invasive species increase in number, they compete with native species for food and habitat, eventually changing the ecosystem." These contrasting responses highlight the uneven development of mechanism-based ecological reasoning among preservice teachers.

This pattern suggests that many preservice teachers may be relying on a simplified heuristic in which non-native status is treated as the defining feature of invasiveness, whereas ecosystem disruption is interpreted as a separate, loosely related outcome. One likely explanation is that invasion-related terminology is frequently communicated in public discourse and school contexts through rule-of-thumb labels (e.g., "alien species = harmful"), which foreground categorical membership over causal ecological mechanisms. As a result, learners may develop label-based reasoning that supports identification of well-known examples but does not readily translate into mechanism-based judgments about when and how a species becomes disruptive (e.g., competition, predation, disease transmission, or population growth thresholds).

From an instructional perspective, such confusion is likely to surface in classroom tasks that emphasize categorization (e.g., listing "invasive species") without requiring justification grounded in ecological processes. If preservice teachers are assessed primarily on recalling examples, they may reproduce socially prominent labels rather than evaluate evidence about establishment, spread, and ecological impact. Teacher education therefore needs to explicitly scaffold the conceptual link between invasiveness (a biogeographic and population process) and disruption (an ecological consequence that varies by context), while also clarifying that the relationship is neither automatic nor uniform. A practical approach is to incorporate case-based modules that require preservice teachers to (a) justify classifications using ecological criteria, (b) articulate plausible mechanisms of impact, and (c) anticipate how impacts may differ across settings (e.g., household release vs. institutional overpopulation).

The Release Paradox: Knowledge-Action Disconnection

One of the most notable patterns observed in this study is the disconnection between preservice teachers' expressed ecological understanding and their recommended actions in household-level decision-making contexts. Many participants articulated concerns about the ecological risks associated with releasing invasive species, yet still endorsed release as a practical solution. This "release paradox" illustrates a persistent challenge in environmental education: the difficulty of translating ecological knowledge into responsible action when competing values and immediate constraints are present. Notably, a substantial subset of participants simultaneously expressed ecological concerns while still recommending release, demonstrating a clear knowledge–action mismatch within individual responses.

This paradox is clearly reflected in individual responses that simultaneously expressed ecological awareness and endorsed ecologically problematic actions. For instance, one participant acknowledged that "releasing invasive species into nature can disrupt ecosystems," yet concluded that "letting it go in a nearby stream is the most realistic option for the family." Another preservice teacher similarly recognized the turtle as an invasive species but justified release by emphasizing practicality, stating that "keeping it at home is no longer possible, so releasing it may be unavoidable." These statements illustrate how ecological knowledge was frequently overridden by immediate practical constraints, revealing an unresolved tension between understanding and action within the same response.

Research on environmental decision-making indicates that individuals often prioritize immediate, tangible concerns over abstract or long-term ecological consequences (Weber, 2006). In the household scenario, factors such as practical caregiving difficulties and emotional attachment created intense pressure to resolve the situation quickly. In contrast, the ecological consequences of releasing a single animal may appear distant or uncertain, making ecologically inappropriate actions seem justifiable.

This pattern also reflects the limited application of population-level reasoning in invasion ecology. Viewing individual releases as isolated events overlooks the cumulative nature of biological invasions, which often emerge



through repeated small-scale releases followed by reproduction in suitable environments. Without an understanding of these cumulative processes, the ecological significance of individual decisions may be underestimated. These findings are consistent with research on socioscientific issues, which shows that teachers frequently struggle to integrate scientific knowledge with ethical and practical considerations in real-world contexts (Sadler, 2011).

Notably, this disconnection often occurred within individual responses, where a single preservice teacher simultaneously articulated ecological concern while endorsing release as an acceptable solution, revealing unresolved tensions between competing reasoning frameworks.

Context Effects and Professional Identity Development

The marked contrast between household and institutional decision-making highlights the influence of context on professional judgment and moral reasoning. Preservice teachers appear to activate different professional identities depending on the setting in which a dilemma is situated, leading to distinct priorities and decision-making strategies. This finding supports research on teacher professional identity, which emphasizes that role enactment is highly context-dependent (Beijaard et al., 2004).

In household contexts, preservice teachers often adopt a facilitative or relational role, prioritizing emotional sensitivity and the immediate needs of students and families. This orientation encourages solutions that minimize interpersonal conflict, even when such solutions conflict with ecological principles. In institutional contexts, however, teachers are more likely to assume a stewardship-oriented identity that emphasizes accountability, ecological responsibility, and systematic problem-solving.

Participant voices further underscore this contextual shift in professional identity. In household contexts, emotional sensitivity was frequently foregrounded, as illustrated by statements such as “the student has already formed an emotional bond with the turtle, so we must consider the child’s feelings first.” In contrast, institutional scenarios prompted a markedly different tone, with participants emphasizing professional responsibility and systemic solutions. For example, one respondent stated that “as a teacher, releasing invasive species is unacceptable; the school must contact appropriate authorities.” These contrasting articulations demonstrate how preservice teachers recalibrated their reasoning according to perceived role expectations, even when addressing the same species. These contrasting articulations suggest that preservice teachers recalibrated their reasoning according to perceived role expectations (“caring counselor” vs. “institutional steward”), thereby shaping which considerations were foregrounded, even when the focal species and ecological risks remained constant.

From an ecological perspective, this context-dependent application of principles is problematic. While the consequences of releasing a single animal may differ in scale from releasing many animals, they do not differ in kind. Repeated individual actions, particularly when socially normalized, can collectively generate significant ecological impacts. These findings suggest that teacher education should explicitly address the consistency of ecological principles across personal and professional contexts and support preservice teachers in recognizing their broader role as environmental leaders.

Although this study was conducted with Korean preservice teachers, the observed context-dependent shifts in decision-making reflect broader challenges in environmental education, suggesting that similar patterns may emerge in other cultural and educational systems where teachers navigate competing ecological, ethical, and relational responsibilities.

Moral Reasoning and Life Ethics in Environmental Decision-Making

The prominence of life ethics in preservice teachers’ reasoning provides important insight into the moral complexity of invasive species management. Many participants expressed strong reluctance toward management strategies that involve harm to animals, reflecting deeply held values related to compassion and the preservation of life. Such values were especially salient in institutional contexts, where decisions affected larger numbers of organisms and carried greater perceived responsibility. Analysis of reasoning patterns indicated that references to life ethics appeared more frequently in institutional scenarios than in household scenarios.

This ethical orientation was explicitly articulated in participants’ responses. One preservice teacher argued that “euthanizing animals is morally wrong because they are living beings,” even when acknowledging ecological risks. Another participant emphasized that “as long as there is any alternative, killing should not be considered.” These statements illustrate how life ethics functioned as a powerful moral constraint on decision-making, often limiting consideration of management strategies that involve harm despite their potential ecological effectiveness.

Such statements were common among responses coded under life-ethics reasoning and suggest that, for many preservice teachers, moral constraints regarding harm to individual animals often limited the perceived acceptability of management options, even when ecological risks were acknowledged.

These findings align with broader discussions in environmental ethics concerning tensions between biocentric and ecocentric moral frameworks (Callicott, 1989). In this study, preservice teachers frequently prioritized the welfare of individual organisms over ecosystem-level considerations, even when ecological consequences were substantial. This prioritization highlights the emotional and ethical challenges inherent in managing invasive species.

From the perspective of moral reasoning in science education, these responses reflect the activation of emotive reasoning processes such as empathy and moral discomfort (Zeidler, 2025). While such responses demonstrate ethical sensitivity, they also underscore the need for integrative moral reasoning that balances compassion with ecological understanding and practical wisdom. Developing such integrative reasoning is essential for preparing teachers to navigate the complex ethical landscapes of contemporary environmental issues.

The increased salience of life ethics in institutional contexts suggests that greater responsibility does not simplify moral reasoning; instead, it intensifies it. Preservice teachers appear to recognize that decisions affecting multiple organisms carry distinct moral weight compared to individual household decisions. This finding reinforces the importance of providing structured opportunities in teacher education for engaging with ethical tensions and developing principled, context-consistent environmental judgment.

These findings suggest that teacher education programs should move beyond presenting ethical dilemmas as abstract discussions and instead provide sustained opportunities for preservice teachers to practice integrating ecological knowledge, ethical reasoning, and context-sensitive judgment within realistic decision-making scenarios.

This study advances research on science teacher education by empirically demonstrating how contextual framing shapes the integration of ecological knowledge, moral reasoning, and professional identity in invasive species decision-making. Together, these findings indicate that preservice teachers' invasive-species decisions are shaped by interacting conceptual, moral, and role-based considerations that shift across contexts.

Educational Implications

The findings of this study suggest several crucial implications for the education of prospective teachers and for environmental education in general. Teacher preparation programs are required to provide explicit education that clearly differentiates between invasive species, naturalized species, and ecosystem-disrupting species, using frameworks such as those proposed by Richardson et al. (2000). This educational approach should move beyond a simple definition to incorporate case studies, such as that of the red-eared slider turtle, which illuminate the contextual and variable impacts of different species and emphasize that ecosystem-disrupting capacity is context-dependent. Pedagogical approaches should prioritize functional and process-based ecological analysis over simplistic categorization, enabling future teachers to understand the mechanisms of competition, predation, habitat modification, and disease transmission, and recognize the dynamic nature of ecological impacts across various species and scenarios.

Teacher education programs must foster the development of robust decision-making competencies. These competencies should involve synthesizing ecological knowledge, ethical reasoning, and the practical challenges encountered in classroom and real-world settings. The socioscientific issues framework (Presley et al., 2013; Sadler, 2011) provides a practical pedagogical approach for integrating these knowledge domains. The present research employs scenario-based learning, which allows preservice teachers to practice complex value-laden decision-making. This study was designed to encourage the development of principled, context-consistent environmental judgment. Structured reflective practices, in which teachers analyze the tensions between their recommended actions and their underlying reasoning, consider alternative strategies, and recognize areas of value conflict, have been shown to further cultivate judgment and professional authenticity.

Building on prior studies that have primarily examined teachers' environmental knowledge or attitudes in isolation, this study demonstrates how preservice teachers' ecological understanding, moral reasoning, and professional identity interact dynamically across contrasting decision-making contexts. By foregrounding context-sensitive knowledge–action tensions, the findings extend existing socioscientific issues research and offer a more integrated model of teacher decision-making in environmental education.

Science teachers occupy a distinctive position within the community's environmental discourse. As such, they shoulder substantial responsibility for the environmental implications of their professional counsel, whether it is imparted within the formal educational setting or in informal counseling contexts. Teacher training programs



should emphasize that ecological principles are universally and consistently relevant, irrespective of situational context, and assist new teachers in developing a clear sense of environmental leadership and stewardship.

In conclusion, environmental decision-making in teacher practice necessitates the explicit development of moral reasoning. Preparation programs must furnish educators with the experience and frameworks to integrate scientific knowledge with environmental ethics, drawing upon practical wisdom (phronesis) tenets that synthesize cognitive understanding, empathy, and principled action (Zeidler, 2025). It is incumbent upon teachers to critically examine the tensions inherent in the balance between organismal welfare and ecosystem integrity. Furthermore, teachers should reflect upon the influence of cultural values and adopt a systematic approach to the moral complexity of contemporary environmental issues.

Limitations and Future Directions

Although scenario-based approaches offer valuable insights into the decision-making processes of preservice teachers, they are not without their limitations. These approaches may not accurately predict real-world behavior that involves genuine consequences, institutional pressures, or time constraints. Future research must employ ethnographic studies, detailed case analyses, and longitudinal tracking of teachers' environmental decisions to validate and expand upon these findings.

The present study focuses exclusively on Korean preservice teachers, and it is important to note that its findings may not be universally applicable to countries or cultures with divergent educational traditions, ecological contexts, or prevailing attitudes regarding human-nature relationships. Cross-cultural comparative research will facilitate a more nuanced understanding of how context influences the management of invasive species.

Moreover, the present study captured a single time point in teacher preparation. Longitudinal research tracing the developmental trajectory of environmental decision-making competencies—across teacher education and into professional practice—will inform the timing and structure of optimal professional development interventions.

Finally, the field would benefit from systematically assessing pedagogical approaches that most effectively foster integrated competencies. Implementing controlled comparisons of scenario-based learning, case studies, fieldwork, and community engagement can potentially identify strategies for teacher preparation that are grounded in empirical evidence. Research that establishes a correlation between classroom practice and subsequent ecological and educational outcomes would elucidate the real-world impact of enhanced teacher environmental literacy and decision-making capacity.

Conclusions

This research reveals fundamental challenges in the decision-making processes of preservice biology teachers regarding invasive species management. Across scenarios, three key findings emerged: preservice teachers demonstrated conceptual confusion between invasive species and ecosystem-disrupting species, exhibited a disconnection between articulated ecological knowledge and recommended actions in household contexts, and applied markedly different decision-making frameworks depending on contextual setting.

Despite articulating ecological knowledge about the impacts of invasive species, teachers frequently recommended actions that were inconsistent with this knowledge when faced with household-level dilemmas, highlighting a persistent gap between understanding and action.

The dramatic context effects observed in this study – with teachers applying fundamentally different decision-making frameworks in household versus institutional settings – highlight the need for teacher preparation programs to develop consistent application of ecological principles across professional and personal contexts. The role of teachers as environmental educators extends beyond the confines of formal instruction, encompassing informal community guidance and education. This expanded responsibility necessitates integrating scientific knowledge, moral reasoning, and practical problem-solving capabilities.

The conceptual lacunae in this research, particularly regarding the distinction between invasive and ecosystem-disrupting species, underscore the need for more sophisticated ecological preparation in teacher education programs. Teachers must possess precise taxonomic knowledge and functional understanding of invasion mechanisms, cumulative impact concepts, and population-level thinking in conservation biology.

These findings suggest clear pedagogical implications for science teacher education. Teacher preparation programs should incorporate structured, scenario-based, and socioscientific learning opportunities that explicitly

support preservice teachers in integrating cognitive, affective, and moral dimensions of environmental decision-making, rather than addressing these competencies in isolated or ad hoc ways.

Considering the findings of this research, the red-eared slider turtle is identified as a compelling case study for developing these integrated competencies. This species simultaneously represents challenges as abandoned pets and as established populations in educational programs, thus exemplifying the multi-layered complexity of contemporary environmental issues. Teachers must navigate scientific knowledge, ethical reasoning, institutional constraints, and community values within coherent decision-making frameworks that are informed by these considerations.

Overall, this study demonstrates that effective invasive species management education requires more than the transmission of knowledge; it demands the cultivation of integrated decision-making competencies.

As invasive species continue to pose increasingly severe threats to biodiversity, science teachers sitting at the intersection of scientific expertise and community decision-making play a crucial role in modeling environmentally responsible and ethically grounded judgment across diverse contexts.

Building on and extending prior research that has largely examined environmental knowledge or attitudes in isolation, this study advances science teacher education theory by empirically demonstrating how ecological understanding, moral reasoning, and professional identity interact dynamically across contrasting contexts of invasive species decision-making. Practically, the findings offer an empirically grounded framework for teacher education that foregrounds knowledge–action coherence, thereby strengthening environmental literacy and supporting more responsible invasive species management across both personal and institutional settings.

Acknowledgements

This work was supported by Korea Environment Industry & Technology Institute(KEITI) through Exotic Invasive Species Management Program, funded by Korea Ministry of Environment(MOE)(RS-2018-KE000335).

Declaration of Interest

The authors declare no competing interest.

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Received: December 03, 2025

Revised: December 20, 2025

Accepted: January 15, 2026

Cite as: Hwang, H., & Lee, J.-K. (2026). Preservice teachers' decision-making on invasive species management: A knowledge-action disconnect across contexts. *Journal of Baltic Science Education*, 25(1), 39–54. <https://doi.org/10.33225/jbse/26.25.39>

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